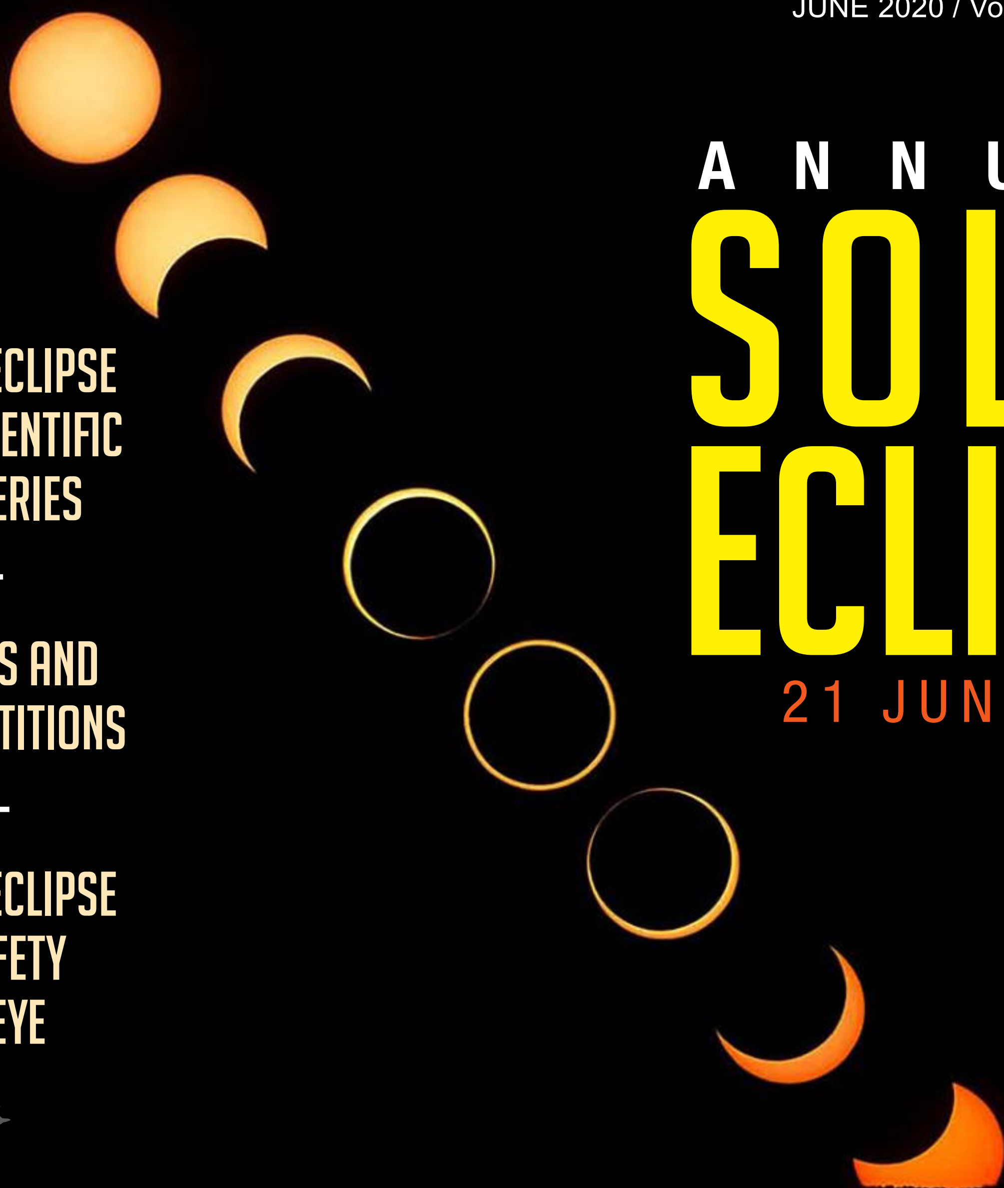
ANNULAR SOLAR ECLIPSE SPECIAL

VIGYAN PRASAR

DREAM 2047

JUNE 2020 / Vol. 22 / No. 9 / ₹ 20



ANNULAR SOLAR ECLIPSE

21 JUNE 2020

SOLAR ECLIPSE AND SCIENTIFIC DISCOVERIES

ECLIPSES AND SUPERSTITIONS

SOLAR ECLIPSE AND SAFETY OF THE EYE

Editor-in-Chief:
Nakul Parashar

Editor:
Nimish Kapoor

Production:
Pradeep Kumar
Bipro Kumar Sen
Amitesh Banerjee

Expert member:
Biman Basu
Sumita Mukherjee

Address for correspondence:
Vigyan Prasar, A-50,
Institutional Area, Sector-62,
Noida-201 309, U.P., India

Tel: +91-120-2404430, 35

Fax: +91-120-2404437

e-mail:
dream@vigyanprasar.gov.in

website:
http://www.vigyanprasar.gov.in

Published and Printed by Dr Nakul Parashar on behalf of Vigyan Prasar, A-50, Institutional Area, Sector-62, Noida-201 309, U.P., India and Printed at Chandu Press, 469, Patparganj Industrial Estate, Delhi 110 092
Telefax: 22424396, 22526936.

Cover Design By: BIPRO KUMAR SEN

Don't miss it: June 21st, 2020

AT the outset, hope you're doing good; please stay safe.

Well, these are times when society's complete focus is on science and technology. The humanity eagerly awaits development of a vaccine to overcome the menace of COVID-19. Labs and pharmaceutical companies all around the globe are racing against time. Time has always been the essence, and this time too, it's no longer an exception. Reports and speculations about the arrival of a practical solution indicate associated timelines as short as the third and fourth quarter of the year.

This has led to an evolution of a new normal. Personal hygiene has gained widespread awareness and, in turn, received a complete global concurrence. Society's acceptance of cleanliness is thus no longer a mere etiquette now.

On a positive note, the efficacy of preventive measures has started to yield results. On the numbers side, areas that were red until a few weeks ago have begun to change their colour. Red to orange and then towards green, the number of positive cases has seen a southward trend in several parts of the world, and in our country too.

With every passing day, we are getting more and more information about the virus, SARS-Cov-2. Speculations with theories that weather and climatic changes play a role in holding the spread of it have been countered too. While the knowledge database is on a quick rise, pandemic to endemic is what most researchers are committing to. We, at Vigyan Prasar, have gone a step ahead. We are continuously producing daily video reports, weekly consolidated newsletters, and monthly newsletters in four different languages – Tamil, Urdu, Bangla, and Kannada. In case you miss any one of them, do not worry. Our website carries them all.

Yet, no matter what; it's wait and keep-a-watch on the latest.

While the pandemic is on, other things in nature continue to happen. Yes, I'm referring to the last annular solar eclipse in India of this decade. 21 June 2020 is the date. The next one that would pass through India would be on 21 May 2031.

Being Sunday and the longest day of the year, the 21 June annular solar eclipse (ASE) this year passes through selected cities and towns of Rajasthan, Haryana, Uttar Pradesh, and Uttarakhand. Interestingly, the duration of annularity is not very long – thirty seconds is the average duration that the path shows at the moment. Selected locations that would witness maximum annularity include Suratgarh in Rajasthan, Behat in Uttar Pradesh, and places near Dehradun in Uttarakhand. With the lockdown on, Vigyan Prasar organised many lectures about the annular solar eclipse that were delivered by its scientists. We have done these in various Indian languages – Tamil, Bangla, Maithili, Urdu, and Marathi – through web video platforms since April 2020. Efforts are being made to organise live telecast of this event through various social media platforms as well. On the print side, please stay tuned as we plan to publish a couple of originally written books in Hindi and English. Thus, to gather information on several related activities, please visit www.vigyanprasar.gov.in, and of course, here is yet another special issue in succession – the Annular Solar Eclipse special issue. I hope that you'll like it, and enjoy watching the annular solar eclipse, but safely!

Email: nakul.parashar@vigyanprasar.gov.in

Dr Harsh Vardhan, Minister of Health and Family Welfare, elected the Chair of World Health Organization's Executive Board

The Union Minister of Health & Family Welfare Dr Harsh Vardhan has been elected as Chair of the Executive Board of World Health Organization for the year 2020-21. This took place on 22 May 2020 during the 147th session of the Executive Board, in a meeting that was virtually held. He has replaced Dr Hiroki Nakatani of Japan.

Accepting the Chair of the Executive Board, Dr Harsh Vardhan paid tribute to the lakhs of people who have lost their lives due to the global COVID-19 pandemic. He requested all dignitaries present on the occasion to give a standing ovation to all the frontline health workers and other COVID Warriors by saluting their dignity, determination and dedication.

"I feel deeply honoured to have the trust and faith of all of you. India, and all my countrymen, too, feel privileged that this honour has been bestowed upon us," he stated. Acknowledging that this is a great human tragedy and the next two decades may see many such challenges, he stated that "All these challenges demand a shared response, because these are shared threats requiring a shared responsibility to act."He further added that "while this is the core philosophy of our alliance of member nations that comprise WHO, however, it needs a greater degree of shared idealism of nations." He said that "The pandemic has made humanity acutely aware of the consequences of ignoring the strengthening and preparedness of our healthcare systems. In such times of global crisis, both risk management and mitigation would require further strengthening of global partnerships to re-energize interest and investment in global public health."

Dr Harsh Vardhan also shared India's experience of combating COVID-19. He noted that "We have a mortality of 3 per cent only. In a country of 1.35 billion, there are only 0.1 million cases of COVID-19. The recovery rate is above 40 per cent and the doubling rate is 13 days."

As the new Chair of the Executive Board of WHO, Dr Harsh Vardhan underlined the need for higher commitments in respect of diseases that have plagued humankind for centuries, collaborations for supplementing each other by pooling of global resources, an aggressive roadmap to curtail deaths from diseases that can be eliminated, a fresh roadmap to address global shortages of medicines and vaccines and the need for reforms. He said, "I am sure that constant engagement with member states and other stakeholders will reinforce reforms and help accelerate progress towards achieving sustainable development goals and universal health coverage with the most productive, efficient and targeted utilization of resources."

Dr Harsh Vardhan stated that WHO believes in the principle that the enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition.

Dr Harsh Vardhan while taking charge as the Chair of the EB also shared his thoughts on the future health scenario of the world. "I believe that health is central to economic performance and to enhancing human capabilities. However, public health policy must be based and guided on a proper understanding of nature. This is also the underlying principle of the Indian traditional systems of medicine based on holistic health and wellness, which I have lived and experienced," he said. He also outlined the policy of India towards 'Universal Health for All' through national flagships programmes such as Ayushman Bharat with its twin pillars of Health & Wellness centres (HWCs) and Pradhan Mantri Jan Arogya Yojana (PMJAY), being led by the dynamic and visionary Prime Minister Mr Narendra Modi.

Reminiscing about his long standing association with WHO, he expressed his gratitude for the strong support of WHO in India's fight against Polio. "If it had not been for the support and morale boosting by friends in WHO, I would not have achieved what I did. If, today, Polio stands eradicated from India, I must admit it could never have been possible without the perseverance of WHO," he stated.

Dr Harsh Vardhan has also been a member of several prestigious committees of WHO like Strategic Advisory Group of Experts (SAGE) and the Global Technical Consultative Group (TCG) on Polio Eradication. He has also served as an Advisor to the WHO.

The Executive Board of WHO is composed of 34 technically qualified members elected for three-year term. The main functions of the Board are to implement the decisions and policies of the Health Assembly and advise and facilitate its work.

In 1994, as the Delhi Health Minister, he oversaw the successful implementation of the pilot project of the Pulse Polio Programme which involved the mass immunisation of 1.2 million children up to the age of 3 in Delhi, laying the groundwork for a Polio free India in 2014. Dr Harsh Vardhan has been the Union Health Minister in 2014, and later took over as the Union Minister Science & Technology and Earth Sciences. He was also Union Minister for Environment, Forest and Climate Change. In 2019 asUnion Cabinet Minister he was given the portfolios of Health and Family Welfare; Science and Technology and Earth Sciences.

Source: PIB

Dr Harsh Vardhan dedicates COBAS 6800 testing machine to the nation

Union Minister of Health & Family Welfare and Science & Technology, and Earth Sciences, Dr Harsh Vardhan visited the National Centre for Disease Control (NCDC), New Delhi and dedicated the COBAS 6800 testing machine to the nation. This is the first such automated diagnostic machine that has been procured by the Government for testing of COVID-19 cases.

COBAS 6800 is a sophisticated machine enabled with robotics that minimizes the chance of contamination as well as the risk of infection to the healthcare workers since it can be operated remotely with limited human intervention. It can also detect other pathogens like Viral Hepatitis B & C, HIV, MTb (both rifampicin and isoniazide resistance), Papilloma, CMV, Chlamydia, Neiserreia, etc.

Assistive tools, technologies and techniques for Divyangjan& elderly during COVID-19

The Department of Science and Technology (DST) has taken several initiatives to mitigate the impact of COVID-19 among Divyangjan and elderly and identified various challenges faced by them for finding technological solutions.

The organizations supported by Science for Equity Empowerment and Development (SEED) Division of DST have been instrumental in developing various assistive tools and techniques that are affordable and adaptable through its programme on Technology Interventions for Disabled and Elderly (TIDE), for creating inclusiveness and universal accessibility for Divyangjan and elderly.

An e-Tool has been developed by Rajalakshmi Engineering College, Chennai to create awareness and impart health and hygiene-related information along with education and entertainment to overcome loneliness of the persons with intellectual disabilities due to COVID-19 pandemic. This will help them to learn with fun through Tabs and mobiles. It can also be converted to other vernacular languages. The Beta Version of the e-tool is used by 200 specially-abled children.

CSIR-NCL develops facemask with better filtration efficiency

Scientists at the National Chemical Laboratory (NCL), Pune, using its patented bacterial nano cellulose technology and nano coating, has developed a facemask with better filtration efficiency compared to the ones commercially available.

The cotton cloth coated in a solution of bacterial cellulose and nano material has been found to be effective in preventing the penetration of bacterial growth. A team of scientists, led by Dr. Syed Dastager, Dr. Mahesh Dharne and Dr Shubhangi Umbarkar prepared the prototype using Spun bond polypropylene medical grade cloth to evaluate bacterial filtration efficiency (BFE), particulate filter efficiency (PFE), breathability, flammability, and splash resistance. The BFE of the CSIR-NCL mask is 99.9% according to the ASTM (American Society for Testing and Materials) standard using aerosols of human pathogen, Staphylococcus aureus, found in the upper respiratory tract and on the skin.

Convalescent Plasma: Potential therapy for COVID-19

Research on convalescent plasma therapy for COVID-19 is set to get a boost with the Department of Biotechnology (DBT) and its public sector enterprise Biotechnology Research Industry Research Council (BIRAC) clearing a proposal from Virchow Biotech Pvt Ltd for support to work on the therapy under DBT's National Biopharma Mission.

Hyderabad-based Virchow Biotech has been commercially manufacturing intravenous immunoglobulin from human plasma since 2013 in a WHO-approved and dedicated plasma fractionation cGMP facility. It has a present capacity to process over 300,000 litres of plasma annually.

The proposed immunotherapy procedure has already received approvals from Drug Controller General of India; Central Drugs Standards Control Organization and funding from BIRAC. The company has proposed to collect plasma from several human convalescent donors for preparing standardized immunoglobulin enriched for anti-COVID antibodies with a specific titer. This treatment is increasingly recognized to treat a variety of diseases for its ability to fight the infection and its immunomodulatory and immunosuppressive activities. In the absence of other proven therapies, it is expected help in reducing the morbidity from the COVID-19 infection potentially saving valuable human lives.

Vigyan Samachar Team

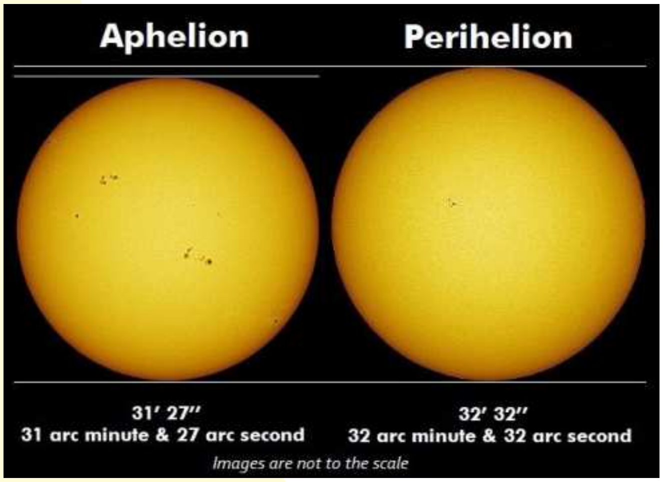
Annular Solar Eclipse: 21 June 2020

Arvind C. Ranade

Since antiquity, there have been solar and lunar eclipses. References of eclipses have also been found in many Hindu religious scripts. For example, in Mahabharata, Lord Krishna says to Arjuna, "See, there is the Sun and here is Jayadratha". The incident refers to Arjuna's vows to kill Jayadratha before the sunset. But, the Sun got eclipsed by the moon, and the entire battlefield became dark, making everyone assume that the sun had already set! Last year there was an annular solar eclipse on 26 December, visible from southern parts of India. The upcoming annular solar eclipse of 21 June 2020 will be visible from parts of northern India.

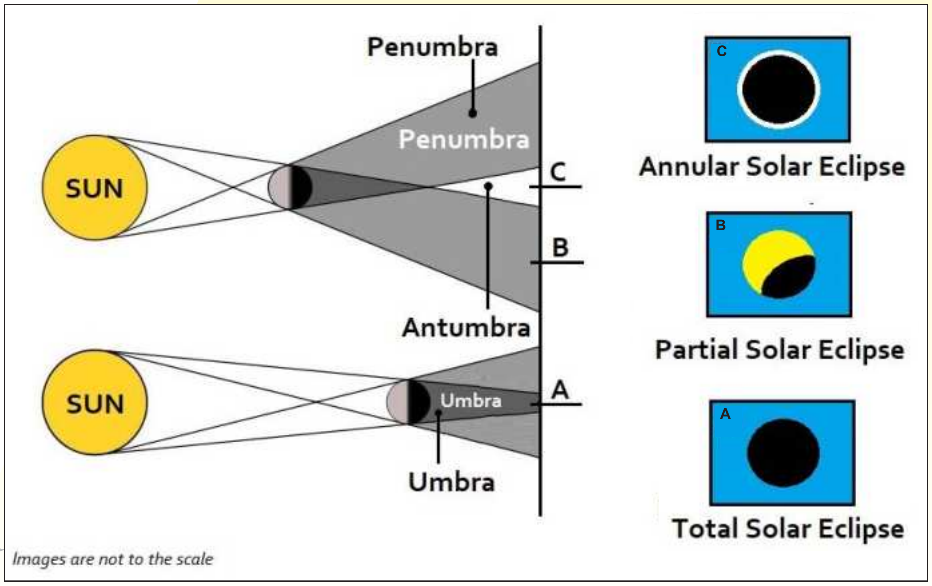
An eclipse is a shadow play, in which one astronomical body gets obscured by another from an observer as a third body comes between. From Earth we can see two types of eclipses; one is solar eclipse in which the Earth passes through the shadow of the Moon on the day of new moon, while the other is a lunar eclipse in which the Moon passes through the shadow of the Earth on the full moon night. Both the Earth's and Moon's shadow is not uniformly dark but has two distinct regions called the umbra and penumbra. The umbra region is the darkest and forms the middle of the shadow while the penumbra, which forms the outer region, is much lighter. For this article, we will restrict to solar eclipses only.

A solar eclipse occurs when the Moon comes between the Earth and the Sun in a straight line on a new moon. Depending on the positions of the three, there can be four types of solar eclipses: (i) Total solar eclipse, in which certain region of the Earth passes through the umbra of the Moon; (ii) Annular solar eclipse, in which certain region of the Earth passes through the antumbra – the region from which the Moon appears entirely within the disc of the Sun, with a bright ring visible around the Moon body; (iii) Partial solar eclipse, in which certain region of the Earth passes through the penumbra of the Moon; and (iv) Hybrid eclipse, a rare type of solar eclipse that changes its appearance – from total to annular – depending on the observer's location along the central eclipse path. Compared to total and the annular solar eclipses, a hybrid eclipse is very rare. The next hybrid eclipse will occur on 20 April 2023 but will not be visible from India.

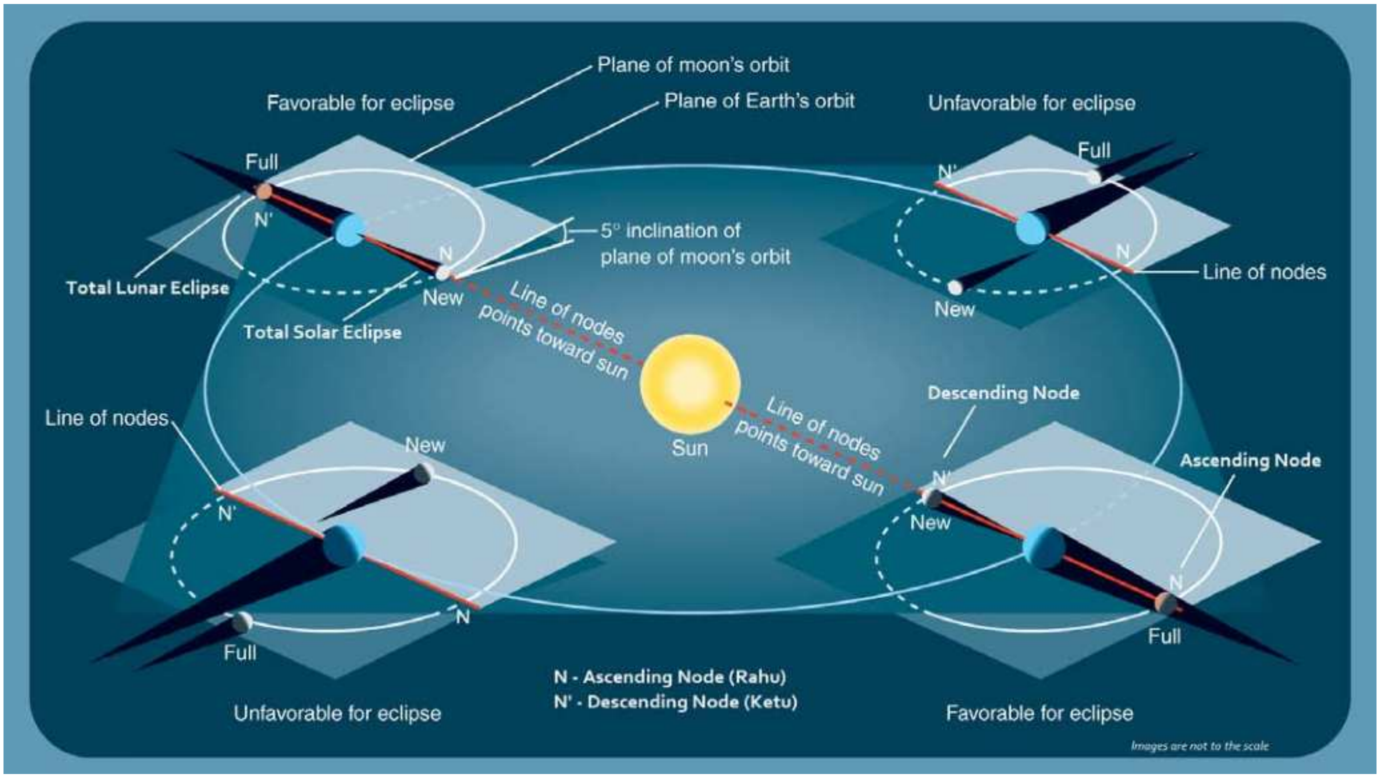


Images are not to the scale

In early 17th century, German astronomer Johannes Kepler had proved that all the planets move in elliptical orbits around the Sun. It implies that when the Sun comes very close to Earth (perihelion), it looks bigger than when the Sun is farthest from Earth (aphelion). In between, the apparent angular size of the Sun varies from 32' 32" (32 arcminutes and 32 arcseconds) and 31' 27" (31 arcminutes and 27 arcseconds). It happens once in a calendar year of 365 days.



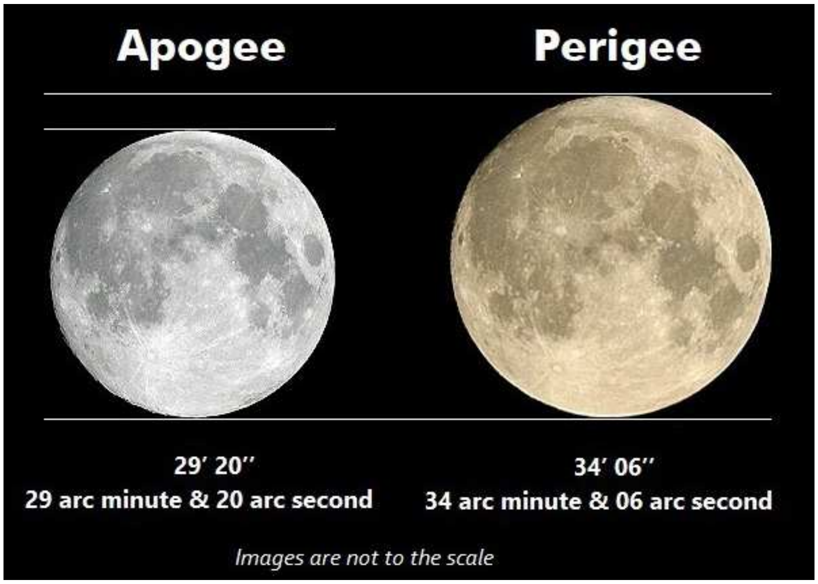
Images are not to the scale



The Moon also revolves around the Earth in an elliptical orbit. Hence, the Moon also comes very close to the Earth at perigee with apparent angular size of 34' 06'' (34 arcminutes and 06 arcseconds) and moves to the farthest point at apogee with 29' 20'' (29 arcminutes and 20 arcseconds). This happens once in 27.32 days as Moon takes 27.32 days to complete one revolution around the Earth. These apparent changes in size of the Sun and the Moon play a significant role in deciding the nature and duration of eclipses.

In one calendar year, there can be at least two and at most five solar eclipses; however, the total number of solar and lunar eclipses cannot exceed seven. As stated earlier, a solar eclipse occurs on a new moon while a lunar eclipse occurs only on a full moon. But we do not observe eclipses on every new moon or full moon. This is because the orbit of the Moon is inclined at 5° to the ecliptic (an imaginary line that marks the path of the Sun in the sky). The ecliptic crosses the orbit of the Moon at two points known as nodes. These points are called ascending node (moon's motion towards north) and descending node (moon's motion towards south). In Indian epics, these points are referred to as Rahu and Ketu respectively. An eclipse can occur only when the Moon is close to or at one of the nodes.

The period of totality and annularity of a solar eclipse depends on the apparent sizes of the Sun and the Moon. The duration of totality ranges from few seconds to a maximum of 7 minutes and 30 seconds. To have the maximum totality, the Earth has to be at aphelion while the Moon has to be at perigee. The maximum duration of totality occurs in the month of July when the Earth is farthest from the Sun. The duration of annularity ranges from a few seconds to a maximum of 12 minutes. To have the maximum duration of annularity, the Earth has to be at perihelion while the Moon has to be at apogee. Annular eclipses with maximum duration usually occur in the month of December. The solar eclipse at the observers' location is referred in terms of magnitude. The magnitude of eclipse is the ratio of angular size of the moon to angular size of the sun. Therefore, partial or annular eclipse will always be less than 1 in magnitude while total solar eclipse can be 1 or more than 1.



Solar eclipses have been observed since ages. The study of eclipses has helped to draw the inference on the shape of the Earth and the Moon. Certain records of eclipse observation have helped historians to draw conclusions about past events, their dates and locations. Till the early 17th century, observations of eclipses were limited to naked eye and data collection. However, after invention

HOW TO OBSERVE THE ECLIPSE?

The eclipse should be observed using authentic and certified solar filters. One should not look at the Sun with naked eyes. One of the best ways to watch the eclipse is through the projection method like ball mirror and pinhole camera. Looking at the Sun with naked eyes can harm our eyes and may result in permanent loss of vision.

VIGYAN PRASAR'S PLAN FOR ANNULAR SOLAR ECLIPSE 2020

In view of the lockdown restrictions in force due to COVID-19, Vigyan Prasar has decided to observe ASE-2020 using the web-based tools and techniques. The plans are as follows:

A. Knowledge Resources on VP's web portal: Beginning 10 May 2020, the documentaries, power point presentations on various topics of astronomy, posters, books and booklet on eclipse and related aspects of the astronomy have been made available. The material can be downloaded from https://vigyanprasar.gov.in/science-communication-programs/astronomy-popularisation/

B. Webinar series for VIPNET clubs of VP: Since 25 April 2020, Vigyan Prasar scientists have been delivering online talks on the Annular Solar Eclipse of 21 June 2020. As of now, more than 25 talks have been delivered with 3,000 affiliated clubs.

C. Online training workshops on ASE: In second phase, Vigyan Prasar will select a few cities from the belt of annularity with active clubs and organisations for hands-on training on how to make a Sun projector, how to observe and how to conduct scientific activities with children. Through these activities, the children can learn about relative velocity of the Sun and the Moon, the duration of eclipse, percentage of eclipse, etc. The training will start from 1 June 2020.

D. Live telecast and streaming of ASE on 21 June 2020: VP has planned to organise live telecasts from five different stations from the annularity belt. The live streaming will be made available on various platforms like VP website, YouTube, Facebook, India Science (OTT platform of VP), etc. The five stations are Suratgarh, Sirsa, Kurukshetra, Yamunanagar and Dehradun.

E. Special issue of Dream 2047 and Curiosity: Curiosity, the newsletter for VIPNET clubs and Dream 2047, the magazine published by Vigyan Prasar have both special issues dedicated to the upcoming Annular Solar Eclipse. Curiosity has focussed on the activity-based articles and do-it-yourself columns on solar eclipse. Dream 2047 issue focuses on understanding the importance and the information of past, present and upcoming eclipses.

LOCAL CIRCUMSTANCES RELATING TO CERTAIN PLACES IN INDIA WHERE THE PARTIAL PHASE IS VISIBLE

Place	Partial Begins	Greatest Phase	Partial Ends	Total Duration of Eclipse	Coverage of Sun	Magnitude
Agartala	10:55:53	12:45:15	14:23:53	3 hours, 28 minutes	69.48%	0.759
Aizawl	11:00:45	12:49:52	14:26:53	3 hours, 26 minutes, 8 seconds	70.88%	0.7703
Amaravati (Andhra Pradesh)	10:20:45	12:02:28	13:49:01	3 hours, 28 minutes, 16 seconds	45.98%	0.5618
Bengaluru	10:12:54	11:47:56	13:32:22	3 hours, 19 minutes, 28 seconds	36.98%	0.4813
Bhopal	10:14:41	11:57:32	13:47:21	3 hours, 32 minutes, 40 seconds	73.00%	0.7873
Bhubaneswar	10:38:11	12:26:12	14:09:54	3 hours, 31 minutes, 43 seconds	56.88%	0.6551
Chandigarh	10:22:03	12:02:05	13:47:06	3 hours, 25 minutes, 3 seconds	96.62%	0.975
Chennai	10:22:08	11:59:04	13:41:32	3 hours, 19 minutes, 24 seconds	34.23%	0.4557
Daman	10:01:51	11:39:33	13:30:00	3 hours, 28 minutes, 9 seconds	67.36%	0.7417
Dispur	10:57:35	12:46:09	14:24:13	3 hours, 26 minutes, 38 seconds	79.98%	0.8433
Gandhinagar	10:04:05	11:42:28	13:32:37	3 hours, 28 minutes, 32 seconds	77.91%	0.8268
Gangtok	10:48:10	12:36:15	14:17:08	3 hours, 28 minutes, 58 seconds	84.21%	0.8769
Hyderabad	10:14:52	11:55:48	13:44:04	3 hours, 29 minutes, 12 seconds	50.25%	0.5989
Imphal	11:04:35	12:53:07	14:28:54	3 hours, 24 minutes, 19 seconds	75.50%	0.8076
Itanagar	11:03:26	12:51:08	14:27:08	3 hours, 23 minutes, 42 seconds	84.40%	0.8785
Jaipur	10:14:48	11:55:57	13:44:23	3 hours, 29 minutes, 35 seconds	88.46%	0.9106
Jammu	10:21:43	11:58:41	13:41:26	3 hours, 19 minutes, 43 seconds	87.36%	0.9019
Kavaratti	09:59:13	11:26:07	13:07:23	3 hours, 8 minutes, 10 seconds	34.19%	0.4553
Kohima	11:04:57	12:53:10	14:28:49	3 hours, 23 minutes, 52 seconds	78.95%	0.8352
Kolkata	10:46:20	12:35:39	14:17:17	3 hours, 30 minutes, 57 seconds	65.52%	0.7266
Leh	10:29:12	12:06:45	13:47:39	3 hours, 18 minutes, 27 seconds	83.96%	0.8749
Lucknow	10:26:38	12:11:49	13:58:42	3 hours, 32 minutes, 4 seconds	84.25%	0.8772
Mumbai	10:00:49	11:37:41	13:27:50	3 hours, 27 minutes, 1 second	62.10%	0.6986
New Delhi	10:20:02	12:01:40	13:48:36	3 hours, 28 minutes, 34 seconds	93.77%	0.9525
Panaji	10:01:47	11:36:37	13:24:42	3 hours, 22 minutes, 55 seconds	48.71%	0.5857
Patna	10:37:06	12:25:04	14:09:35	3 hours, 32 minutes, 29 seconds	77.70%	0.825
Port Blair	11:14:31	12:52:35	14:18:25	3 hours, 3 minutes, 54 seconds	27.70%	0.3929
Puducherry	10:21:31	11:56:02	13:36:59	3 hours, 15 minutes, 28 seconds	30.91%	0.4241
Raipur	10:24:57	12:10:50	13:58:35	3 hours, 33 minutes, 38 seconds	62.19%	0.6992
Ranchi	10:36:44	12:25:07	14:09:52	3 hours, 33 minutes, 8 seconds	68.87%	0.7539
Shillong	10:57:50	12:46:39	14:24:39	3 hours, 26 minutes, 49 seconds	77.78%	0.8258
Shimla	10:23:27	12:03:32	13:48:06	3 hours, 24 minutes, 39 seconds	95.46%	0.9659
Srinagar	10:24:04	11:59:44	13:40:45	3 hours, 16 minutes, 41 seconds	82.20%	0.861
Thiruvananthapuram	10:14:52	11:40:01	13:15:14	3 hours, 22 seconds	23.21%	0.3473

Note: All timings are in Indian Standard Time (IST)

LOCAL CIRCUMSTANCES RELATING TO CERTAIN PLACES IN INDIA WHERE THE ANNULAR PHASE IS VISIBLE

Place	Partial Begins	Full Begins	Greatest Phase	Full Ends	Partial Ends	Total Duration of Eclipse	Duration of Annularity	Coverage of Sun	Magnitude
Gharsana (Rajasthan)	10:12:26	11:50:08	11:50:20	11:50:32	13:36:56	3 hours, 24 minutes, 30 seconds	24 seconds	98.89%	0.9956
Anupgarh (Rajasthan)	10:12:59	11:50:43	11:50:52	11:51:04	13:37:22	3 hours, 24 minutes, 23 seconds	21 seconds	98.89%	0.9949
Bhagsar (Rajasthan)	10:13:16	11:51:15	11:51:27	11:51:36	13:38:03	3 hours, 24 minutes, 47 seconds	21 seconds	98.90%	0.9953
Sri Vijaynagar (Rajasthan)	10:13:33	11:51:29	11:51:44	11:51:59	13:38:13	3 hours, 24 minutes, 40 seconds	30 seconds	98.90%	0.9958
Suratgarh (Rajasthan)	10:14:25	11:52:39	11:52:54	11:53:09	13:39:20	3 hours, 24 minutes, 55 seconds	30 seconds	98.90%	0.9966
Amloha (Haryana)	10:21:50	12:02:16	12:02:34	12:02:49	13:48:11	3 hours, 26 minutes, 21 seconds	33 seconds	98.95%	0.9969
Ellenabad (Haryana)	10:16:02	11:54:55	11:55:07	11:55:19	13:41:30	3 hours, 25 minutes, 28 seconds	24 seconds	98.92%	0.9958
Gumthala Gadhu (Haryana)	10:20:30	12:00:35	12:00:50	12:01:05	13:46:43	3 hours, 26 minutes, 13 seconds	30 seconds	98.94%	0.9971
Sirsa (Haryana)	10:16:52	11:56:02	11:56:14	11:56:26	13:42:32	3 hours, 25 minutes, 40 seconds	24 seconds	98.92%	0.9956
Ratia (Haryana)	10:18:10	11:57:39	11:57:54	11:58:09	13:44:04	3 hours, 25 minutes, 54 seconds	30 seconds	98.93%	0.9963
Jakhal (Haryana)	10:18:49	11:58:26	11:58:41	11:58:56	13:44:45	3 hours, 25 minutes, 56 seconds	30 seconds	98.93%	0.9968
Pehowa (Haryana)	10:20:35	12:00:44	12:00:59	12:01:14	13:46:47	3 hours, 26 minutes, 12 seconds	30 seconds	98.94%	0.9963
Kurukshetra (Haryana)	10:21:06	12:01:28	12:01:40	12:01:55	13:47:27	3 hours, 26 minutes, 21 seconds	27 seconds	98.95%	0.9962
Ladwa (Haryana)	10:21:34	12:02:05	12:02:17	12:02:29	13:48:02	3 hours, 26 minutes, 28 seconds	24 seconds	98.95%	0.9957
Yamunanagar (Haryana)	10:22:16	12:02:51	12:03:03	12:03:18	13:48:39	3 hours, 26 minutes, 23 seconds	27 seconds	98.95%	0.9963
Jagadhari (Haryana)	10:22:20	12:03:00	12:03:09	12:03:18	13:48:42	3 hours, 26 minutes, 22 seconds	18 seconds	98.95%	0.9953
Talwara Khurd (Haryana)	10:16:05	11:54:49	11:55:07	11:55:22	13:41:27	3 hours, 25 minutes, 22 seconds	33 seconds	98.92%	0.9968
Behat (Uttar Pradesh)	10:22:59	12:03:48	12:04:03	12:04:18	13:49:30	3 hours, 26 minutes, 31 seconds	30 seconds	98.95%	0.9968
Bahmanwala (Uttarakhand)	10:24:00	12:05:03	12:05:15	12:05:27	13:50:32	3 hours, 26 minutes, 32 seconds	24 seconds	98.96%	0.9956
Chandrapuri (Uttarakhand)	10:26:30	12:08:07	12:08:22	12:08:37	13:53:13	3 hours, 26 minutes, 43 seconds	30 seconds	98.96%	0.9965
Dehradun (Uttarakhand)	10:24:07	12:05:18	12:05:21	12:05:27	13:50:35	3 hours, 26 minutes, 28 seconds	9 seconds	98.96%	0.9948
Chamba (Uttarakhand)	10:24:53	12:06:10	12:06:22	12:06:37	13:51:31	3 hours, 26 minutes, 38 seconds	27 seconds	98.96%	0.9962
Marora (Uttarakhand)	10:24:36	12:05:53	12:05:59	12:06:02	13:51:06	3 hours, 26 minutes, 30 seconds	9 seconds	98.96%	0.9947
New Tehri (Uttarakhand)	10:25:08	12:06:30	12:06:39	12:06:48	13:51:43	3 hours, 26 minutes, 35 seconds	18 seconds	98.96%	0.9952
Augustmuni (Uttarakhand)	10:26:22	12:08:02	12:08:17	12:08:29	13:53:09	3 hours, 26 minutes, 47 seconds	27 seconds	98.96%	0.9967
Chamoli (Uttarakhand)	10:27:30	12:09:23	12:09:38	12:09:53	13:54:20	3 hours, 26 minutes, 50 seconds	30 seconds	98.97%	0.9971
Gopeshwar (Uttarakhand)	10:26:58	12:08:52	12:09:04	12:09:16	13:53:54	3 hours, 26 minutes, 56 seconds	24 seconds	98.97%	0.9958
Pipalkoti (Uttarakhand)	10:27:14	12:09:14	12:09:23	12:09:35	13:54:11	3 hours, 26 minutes, 57 seconds	21 seconds	98.97%	0.9957
Tapoban (Uttarakhand)	10:24:16	12:05:26	12:05:32	12:05:35	13:50:44	3 hours, 26 minutes, 28 seconds	9 seconds	98.96%	0.9948
Joshimath (Uttarakhand)	10:27:43	12:09:40	12:09:52	12:10:04	13:54:27	3 hours, 26 minutes, 44 seconds	24 seconds	98.97%	0.9958

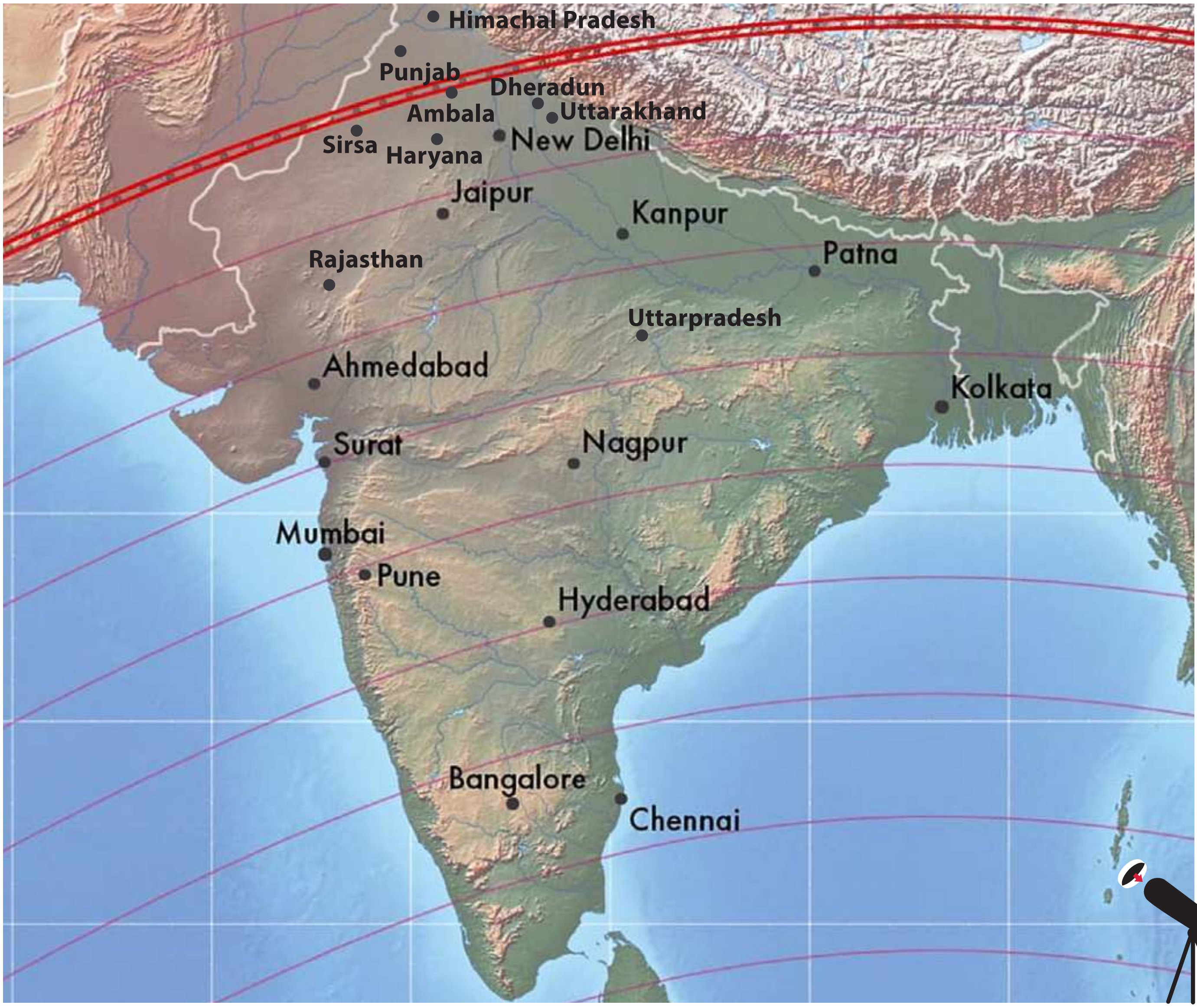
Note: All timings are in Indian Standard Time (IST) of the telescope and advancement of technology, there has been tremendous progress in understanding of the Sun's atmosphere as well as its internal structure. Indeed, nowadays we need not wait for a natural solar eclipse to conduct any scientific experiments, because eclipses are simulated through modern techniques.

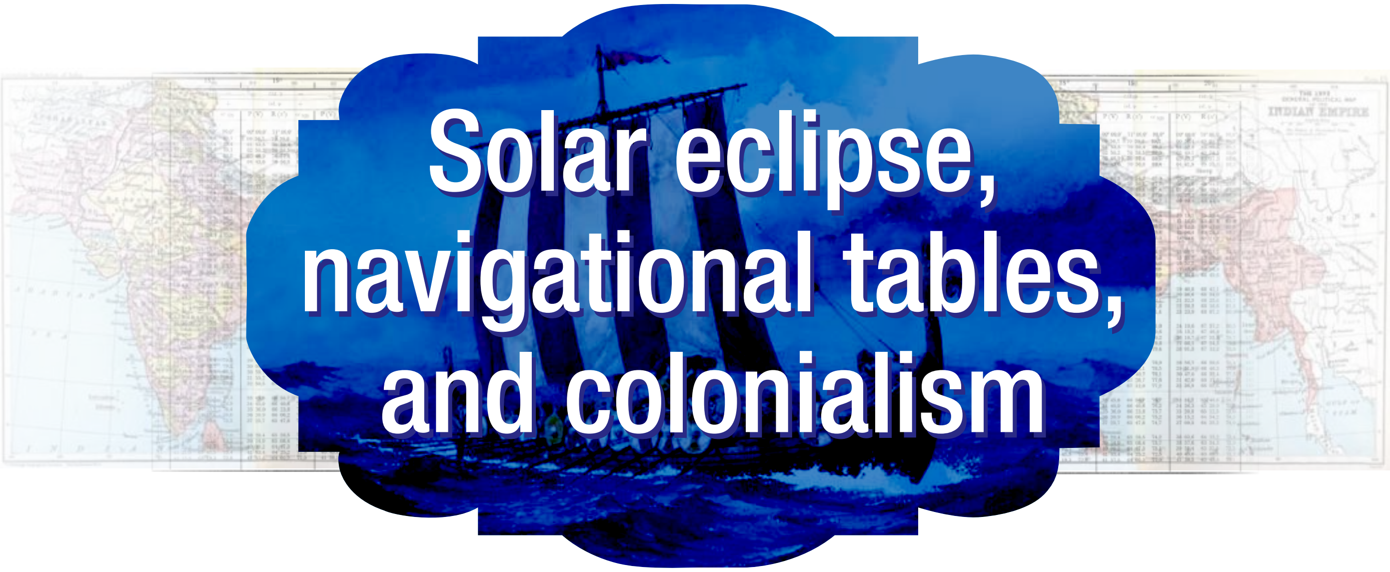
Annular Solar Eclipse of 21 June 2020

The annular phase of the annular solar eclipse of 21 June will start from the Central African Republic in the morning hours and will then proceed to Congo, Ethiopia, Yemen, Saudi Arabia, Oman, Pakistan, India, China and Taiwan. It will end in the evening in South Pacific Ocean, as shown in the global map.

On 21 June, only four states of northern India, namely Rajasthan, Haryana, part of Uttar Pradesh, and Uttarakhand will be able to witness the annularity. However, entire India will witness the partial phase of the eclipse. Annularity will enter India from west Rajasthan, the first town to see it is Gharsana. As per Indian standard time, the first contact will start at 10 hours 12 minutes and 26 seconds. The annularity will start at 11 hours 50 minutes and 08 seconds and will end at 11 hours 50 minutes and 32 second, thus making it only 24 seconds of annularity at Gharsana. The fourth and the last contact will be at 13 hours 36 minutes and 56 seconds. The annularity will pass through Anupgarh, Sri Vijaynagar, Suratgarh of Rajasthan and will enter Haryana from Ellenabad and then progress to Sirsa, Ratia (Fathehabad), Jakhal, Pehowa, Kurukshetra, Ladwa, Yamunanagar to Jagadari and touch upon Behat district of Uttar Pradesh (UP). Behat is the only major town from UP where the annularity will be visible. From UP, annularity enters Uttarakhand and passes via Dehradun, Chamba, Tehri, Agastmuni, Chamoli Gopeshwar, Pipalkoti, Tapowan and finally the annularity will leave India from Joshimath. At Joshimath, eclipse will start at 10 hours 27 minutes and 43 seconds with first contact and annularity will start 12 hours 09 minutes and 40 seconds and will end at 12 hours 10 minutes and 04 second giving rise to only 24 seconds of annularity at Joshimath. The fourth and the last contact will be at 13 hours 54 minutes and 27 seconds.

Dr Arvind C. Ranade is Scientist 'F' in Vigyan Prasar.
Email: rac@vigyanprasar.gov.in





Solar eclipse, navigational tables, and colonialism

T.V. Venkateswaran

The practical aims of geography, to determine the latitude and longitude of a location, navigation, and to improve the accuracy of the moon tables, gave impetus to solar eclipse observations during the eighteenth century.

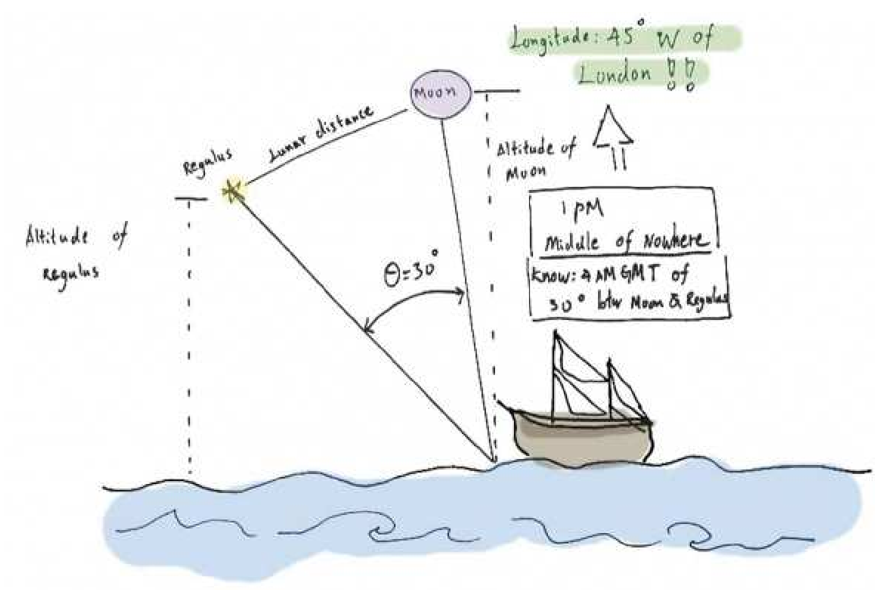
São Gabrie, the flagship of Vasco da Gama's armada, commanded by Nicolau Coelho, gently entered the river Tagus, the longest river on the Iberian Peninsula in southwestern Europe, occupied by Spain and Portugal, on 12 July 1499. The news electrified the whole of Europe; the Portuguese had finally reached India by sea. European merchants, Nobles and Kings danced with joy. Since the conquest of the Constantinople, in 1453, a city that connected the Europe and Asia-Minor, by the Ottomans, European traders were in search of a sea route to Asia, in particular to India. The Ottomans levied very high trade taxes on the European transit goods passing through their land. Since this feat, Vasco da Gama was hailed as a hero in the European imagination. The daring voyage, in search of spices and silk, had commenced on 8 July 1497 with 170 sailors and a fleet of four ships. It went around the African continent and finally reached Kozhikode (Calicut) on 20 May 1498.

The incident spurred what is celebrated in European history as the 'age of voyages', which lasted until the 17th century. The period is marked by the European exploration of the world by sea in search of new trading routes, wealth, and knowledge. Ships sailing to the Americas, distant Australia, islands of Caribbean, just dots and blobs on the world map, became a routine affair.

Not getting lost

The perils of sailing in the seven seas included storms, hurricanes, typhoon, pirates, attack by rival kingdoms and occasional mutiny by the sailors against tyrant captain of the fleet. But nothing was a more significant challenge than to calculate latitude and longitude of the ship. Knowing your place in the high seas often meant life or death. Moreover, when a new island was found and a natural port was discovered in distant lands, they needed to be marked on the world map. To leave a permanent mark in the world map, the latitude and longitude of the place needed to be computed.

Knowing your latitude and longitude was a paramount stumbling block. However, finding the latitude was relatively easy. The altitude of North Star (Pole Star) above the horizon readily gives your latitude. During daytime, or if the ship is in the southern hemisphere, the Pole Star is of no use. However, by measuring the altitude and azimuth of a known bright star (or the Sun), whose RA (right ascension) and Dec (declination) is precisely known, local sidereal time, and with a bit of spherical trigonometry, one can determine one's latitude. Tables provided in the Nautical Almanac can help in computing the latitude. By 1700, finding latitude at sea was routine and reasonably accurate.



The longitude problem

Computing the longitude however was more difficult. The sailors often had to resort to dead reckoning, a process in which the current position was determined using a previously known location of the ship, say when it was in the port of call and using the estimated speeds over elapsed time and course to guess its current position on a navigational chart. This method was subject to cumulative errors, and often the sailors reached a totally different place than intended. Meandering in the seas, the ships took longer than the necessary time to reach their destinations. With the sea voyages extending beyond the initial estimates, the food stocks ran low, the crew were fed with short rations, leading to various deficiency diseases like scurvy.

Navigation relying on dead reckoning at times wrecked the fleet and left the sailors dead. A famous case is the squadron of British Royal Navy ships that were returning from Gibraltar in October 1707. The weather was overcast and stormy. The navigators of the fleet estimated that they were sailing near the island of Ushant off Brittany in France, while actually, they were near the Isles of Scilly, off the coast of Cornwall, UK. Later that night four ships rammed into the rocks near the Scilly Islands and thousands of sailors lost their lives at sea. It was one of the worst maritime disasters in British history of that time. The public furore forced the British government to enact the Longitude Act of 1714. Rewards were instituted for anyone coming up with a viable solution to the problem of finding longitude at sea.

Greenwich Time

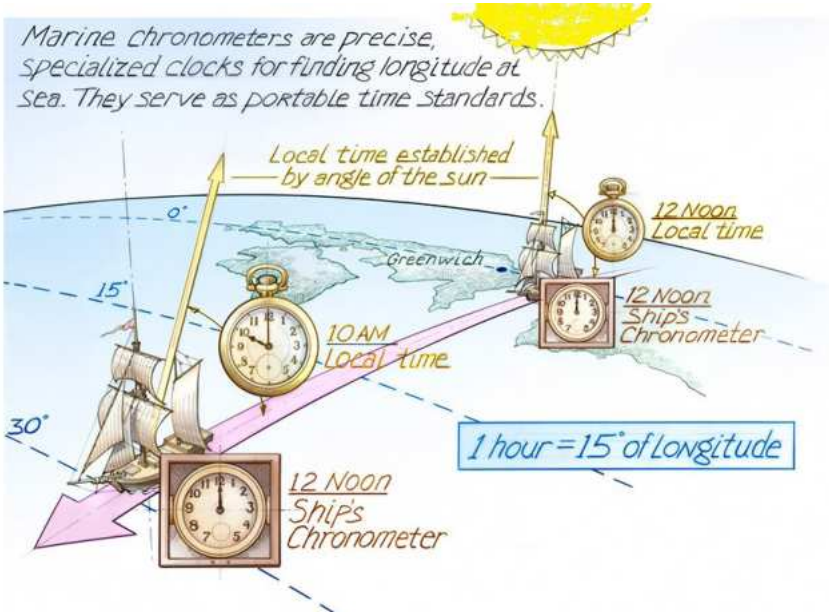
If the British announced the Longitude Prize "for such person or persons as shall discover the Longitude" and demonstration of a practical method for determining the longitude of a ship at sea, other seafaring European nations did not lag behind. Académie Royale des Sciences of France offered two Prix Rouillés specifically for navigation from 1715 onward. Spain and Holland also joined the fray. Navigators and scientists proposed various methods.

It is easy to see that if the time at Greenwich (which was used as the standard reference point) was, say noon, a place 15 degrees longitude west of Greenwich will have a local time of 11 am. A position 15 degrees east of Greenwich will have a local time of 1 pm. In short, the relation between local time and Greenwich Time will be 15 degrees longitude for an hour of difference. If the captain could determine the local time and can compare it with Greenwich Time, the longitude of the location of the ship could be easily computed. Each hour of difference between the Greenwich time and the local time imply 15 degrees of longitude. Finding local time is not a complication. The sundial or a star at the horizon would provide the local time. Thus, the question of finding the longitude reduces to finding the time at Greenwich.

This can be done in two ways. One, you can carry a seaworthy clock that is set to Greenwich Time. The marine chronometer invented by John Harrison relied on this method. Second, you can use the method of lunar distances to determine Greenwich Time advocated by British Astronomer Royal Nevil Maskelyne based on the process first proposed by Tobias Mayer.

Lunar distance method

The "Lunar Distance Method" is a way of finding Greenwich Mean Time and indirectly the longitude of an arbitrary position on Earth by measuring the angular distance between the Moon and a prominent reference celestial object such as the Sun, planets or stars. First published in 1763 by Tobias Mayer, a German astronomer, the method relied on the swift and consistent change in the position of the Moon against the background stars. The Moon makes a complete circle and return to the same position in the background of stars in 27.3 days (the sidereal month) like the hour hand of a clock makes one rotation in 12 hours. With the background stars along the ecliptic serving as the numbers on the dial to read the time and the motion of the Moon as the rotating hands of the clock, one can determine the time at that instant.



As the motion of Moon is predicable to very high accuracy, one can publish a table which pairs the time, in terms of Greenwich Mean Time, with the angular distance of the Moon and a celestial reference object. When the navigator wants to find the longitude, he uses a sextant to measure the angular distance between the Moon and a celestial reference object, at that instance. The almanac tables give geocentric lunar distances. The lunar distance is nothing but the angular distance between the Moon and a reference object, as they would appear from the centre of the Earth. Further, depending upon the altitude of the Moon and the reference object, atmospheric refraction would also mar the observation. Therefore, the observed lunar distance has to be corrected for the effects of atmospheric refraction and parallax to obtain correct lunar distance. The navigator then consults the tables to find out at which Greenwich Time the Moon and that reference object would have the observed angular distance. Voila! They have found the Greenwich Time. Now it is only the question of finding the local time and computing the difference in local and Greenwich Time. You have found the longitude of your location, within a few kilometres of error.

The Nautical Almanac

The idea was first proposed by Tobias Mayer, the German astronomer and superintendent of the observatory at Göttingen in 1755 to British board of longitude. James Bradley, the Astronomer Royal at that time found the tables to be accurate within half a degree, but this required involved calculation and was time-consuming. A significant impediment to practically adopting this method was the mathematics involved in determining time and longitude by lunar distance that remained beyond the grasp of most seafarers.

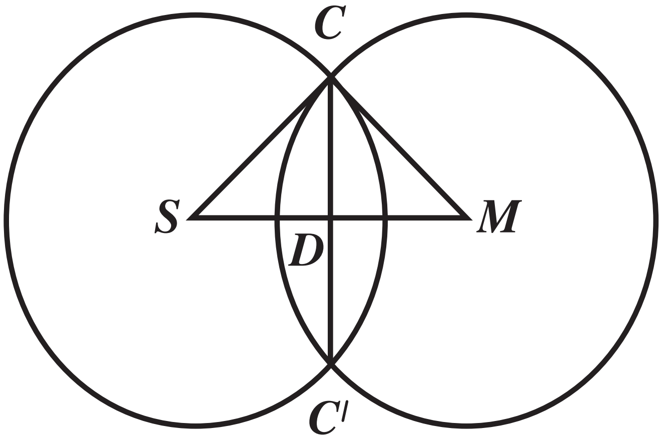
Nevil Maskelyne, who in 1765 was appointed as Astronomer Royal, found a solution. Why not publish detailed tables and simple formulas. The navigators would need to only plug in the observed measurement, such as the altitude of the Moon and reference object as well as the angular distance. With simple arithmetical computation, one could obtain the longitude. Using the Mayer's tables as the starting point, Maskelyne commenced the publication of the Nautical Almanac since 1767 from the Royal Greenwich Observatory. Thirty-five human computers, including a sole woman, Mary Edwards, were employed between 1765 and 1811 by the Royal Observatory for the computation of the tables.

In its heydays, the tabulated distances in the Nautical Almanac were given at three-hour intervals for various reference celestial bodies. The Sun, the planets like Mars, Venus and Jupiter, bright stars like Sirius, Aldebaran, Altair, Antares, Fomalhaut, Hamal, Markab, Pollux, Procyon, Betelgeuse, Rigel, Regulus, and Spica were some of the significant reference objects for which the lunar distance was pre-computed and published as tables. Soon the Greenwich Mean Time became the standard. Prominent European voyagers, including James Cook, used the lunar distance method and the Nautical Almanac for their explorations.

Finding accuracy

With life and property at the mercy of the almanac tables, it is natural that the astronomers and navigators wanted to verify and ensure the accuracy of these predicted positions of the Moon, planets and the Sun in the celestial sphere. What else but the eclipses of the Sun provide an opportunity to verify the expected location with the actual observation of the Sun and the Moon in the sky. The timings of the first and last contact during an eclipse provided the exact position of the Moon and hence to derive corrections for its ephemeris. One could compare various tables to see which one is closer to the observed value.

Initially, the observations were made simply by watching the Moon make the first or last indentation on the Sun's limb. The scintillation on the Sun's limbs and the irregularities of the Moon's contour made the precise timing of these events difficult. With the arrival of the micrometer screw gauge for the measurement of the cusp provided a way out. Francis Baily, an English astronomer and president of Royal Astronomical Society asserted, "...in eclipses of the Sun, the measurement of the distances of the solar cusps affords one of the best means of determining the beginning and end of the eclipse". Astronomers measured the angular distance of the chord between the cusps (or horns) during the partial phase of the eclipse to interpolate the contact timings.



In the figure, let S and M be the centres of the discs of Sun and Moon, respectively. As the Moon makes ‘contact’ over the surface of the Sun, the partial phase commences. The points of the intersection of both the circles, C and C’ in the above, called cusp (or horn), form a chord. The angular distance between these two points, CC’, during various stages of the progress of the partial eclipse, can be measured with a double-wire micrometer. The series of measurements CC’1, CC’2, CC’3... for time t1, t2, t3..., when plotted with the measure of the chord as a function of time, by extrapolating the curve we can obtain the precise contact time of the limbs of Moon and Sun.

Solar eclipse observations

Astronomers were often extolled to take up the telescope, observe and provide precise details on the contact timings. Measuring the distance of the cusp formed the standard protocol during the late 18th century and early 19th century solar eclipse observations. Rev. Professor Powell of the British Association for the Advancement of Science, Oxford while drawing up a memoir for observing the Annular Eclipse of 9 October 1847, suggested to the observers that the “principal object must be to make several measures of the distance between the cusps about the time when that distance is smallest”.

Until then, an observation of a solar eclipse was nothing more than an astronomical spectacle for its observers and a means to provide substantiation for theories predicting its occurrence. However, with the practical utility of eclipse observations, to verify and validate competing tables used by the navigators and geographers, has elevated the eclipse observation exercise from a mere pastime or a curiosity to a scientific activity. Armed with improved Nautical Almanac, European ships reached corners of the world and European astronomers were behind the scene that triggered the age of voyages and subsequently establishment of colonies worldwide.

Dr T.V. Venkateswaran is Scientist 'F' in Vigyan Prasar.
Email: tvv@vigyanprasar.gov.in

Annular solar eclipse: An amazing celestial show

B.K. TYAGI

I remember the day of 16 February 1980, it was probably the first total solar eclipse that was to be seen from India after independence. The scientific community was making its full preparations on this occasion. Astronomers and meteorologists were preparing to carry out their experiments. Doordarshan aired a popular film "Chupke Chupke", to keep people indoors on the day of the eclipse. The government was, perhaps, afraid that people may damage their eyes by looking at the eclipse with naked eyes. Or, we were not ready to consider that event as an opportunity for science popularisation. However, during the telecast of the film, Doordarshan had shown various stages of eclipse at regular intervals. The chance that we had got to dispel the myths and superstitions associated with the event was therefore lost; it rather helped to strengthen them. The roots of age-old traditions and superstitions could hold firmer grounds!

But the total solar eclipse of 24 October 1995 was an exception. This day was the day of Diwali. According to the traditions, the day of an eclipse is not considered auspicious, so Diwali had to be celebrated a day in advance. However, this time there were full preparations to celebrate the eclipse as an event. The preparations by the National Council of Science and Technology Communication (NCSTC) of Department of Science and Technology and Vigyan Prasar were started about six months in advance. A variety of popular course materials were prepared, including information related to solar and lunar eclipses, topics of eye structure and ways to watch a solar eclipse safely, and what to do and what not to do at the time of eclipse, etc. and it was made sure that they reach the common people through various publications. All government and non-government institutions associated with science communication were involved in this effort. Many films related to eclipse were produced, which were telecast by Doordarshan from time to time. An astronomy kit was developed by the Vigyan Prasar and NCSTC in which the science of eclipse was explained by activities in the common man's language. One of the main components of this kit was the "solar filter". By placing this solar filter in front of the eyes, the eclipse could be seen directly without any danger. The black film used in the filter reduced the light coming from the sun by almost a million times. The use of welder's glass no.14 was also suggested for safe looking at the eclipse. Astronomy kits and filters were made available to all organisations and they were sold by Vigyan Prasar. I remember the long queues we had at the office of Vigyan Prasar about two days before the eclipse. This time the general public, indeed, was ready to celebrate the solar eclipse as an event.

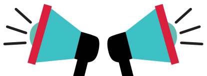
The names Neem ka Thana and Akbarpur of Alwar district, Rajasthan are often referred to in context of the total solar eclipse of 24 October 1995. These two places had a clear view of the total solar eclipse. Scientists and science communicators had camped there two days before the event and had started preparing for various experiments. A day before the eclipse, from Delhi many buses left for the camp organised by Vigyan

Apart from India, there are many other civilisations where many beliefs and myths about solar eclipse and comets are prevalent. In China it is believed that an eclipse is caused by a dragon devouring the Sun. Eskimos believe that the eclipse occurs when the Sun becomes ill. You can list other such popular beliefs.

Prasar and NCSTC. In this venture, not only the employees of the Department of Science and Technology and their families took part, but many children and their parents also showed their interest to see the solar eclipse and joined the camp. At the Akbarpur camp, a day before the event, many activities were organised, which included directly observing the eclipse in a safe manner, photography, and observing the Sun at the time of eclipse by telescope and other means. I was also present in the camp as an organiser. I started from my home loaded with eagerness, curiosity and a fear of eclipse which was buried deep in my heart since my childhood.

But when the solar eclipse started in the morning and we got involved in the process of watching it, the fear took a back seat and its place was taken by pure curiosity and eagerness. That view of a total solar eclipse is still alive in my memories. That halo of the corona around the Sun at the time of totality, the diamond ring, and the Baily's beads still revolve before my eyes as a dream sequence.

After the total solar eclipse, whenever a natural phenomenon, such as the arrival of a comet, meteor shower, ransit of planets or lunar and solar eclipse, etc. happens, Vigyan Prasar makes use of the opportunity to popularise the science of astronomy and dispel the myths and superstitions from common people and students. The year 2009 was declared the year of astronomy. That year, Vigyan Prasar had created a nationwide project for all government, non-government and Vipnet Science Clubs. This project included production and broadcast of radio series and films and production and dissemination of special course materials in which both the Newsletters of Vigyan Prasar had played a pivotal role. Vigyan Prasar, through its website and newsletters, had instructed all science clubs to implement some projects related to astronomy. The members of the science clubs were invited to Bhopal (Madhya Pradesh) to observe the total solar eclipse of 21July 2009 and to Kanyakumari, (Tamil Nadu) to observe the annular solar eclipse of 15 January 2010, in special camps held there. In both these camps, more than one thousand members of Vipnet clubs of the country participated. Some of the activities performed are detailed here which you can perform yourself or with your parents, friends and club coordinators before and during the upcoming annular solar eclipse of 21 June 2020.



Activities you can do before the solar eclipse

❍ Awareness campaign

1. Even today, there are many myths and superstitions prevailing in our society about solar eclipse. You can conduct an awareness campaign in your school and neighbourhood explaining the science of eclipse.

2. By interacting with the people in your neighbourhood, you can make a list of myths, traditions and superstitions related to the eclipse and draw inferences about the logic behind these traditions and norms.

3. Make common people and students aware of ways to watch the eclipse safely. If necessary, you can organise a workshop on making eclipse viewing equipment, etc.

❍ Daytime astronomy activities

4. In order to arouse interest of your peers in astronomy, daytime astronomy activities can be organised with the help of CDs developed by Vigyan Prasar. This will help the students to get interested in astronomy.

5. On the basis of the material developed by Vigyan Prasar, you can give talks and organise exhibition of posters and books.

6. You can display films based on eclipse and astronomy developed by Vigyan Prasar.

7. You can collect stories, songs and poems related to eclipse. For this you can also organise small competitions for the members of your clubs and send your report to Vigyan Prasar; your report may find a place on our website or newsletter.

8. You can prepare a project on places of historical importance associated with astronomy or ancient astronomy.

9. Astronomy, as you know, is the oldest science. Many tools for identifying the constellations, calculating their position, etc., are being developed since time immemorial. You can learn their procedure of working and prepare a report.

10. Apart from India, there are many other civilisations where many beliefs and myths about solar eclipse and comets are prevalent. For example, in China it is believed that an eclipse is caused by a dragon devouring the Sun. To frighten it away, drums are beaten and crackers are burst. An African tribe believes that the Sun's fire calms down and so it turns black. So, fire arrows are thrown towards the Sun to rekindle it. Eskimos believe that the eclipse occurs when the Sun becomes ill. You can list other such popular beliefs.

Pin-hole projected experiments during solar eclipse

Figure: 1

(1) When a beam of sunlight passes through the leaves of a tree and reaches the ground, it produces a pin-hole camera-like effect. If you are standing under a tree at the time of eclipse, you can see the images of the different stages of the eclipse formed in the shade of the tree (see Figure 1). You can see this effect at any time of the day under a tree (Figure 2). Actually, these are the small inverted images of the Sun projected on the ground.

Figure: 2

(2) By laying a white sheet under a tree, you can also take pictures of different stages of the eclipse.

ANNULAR SOLAR ECLIPSE ON 21 JUNE 2020

ACTIVITY-1

Finding the time of maximum Annularity

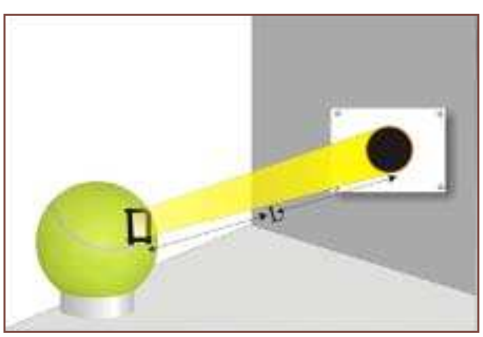
Background

Solar eclipse occurs when Sun, Moon and Earth come in a straight line. During the eclipse the shadow of Moon falls on Earth along a narrow band of land. The eclipse can be seen only from this narrow region. The percentage of the eclipse visible at a given location depends on the how much of the Sun's disk gets obscured by Moon as seen from that location. The time at which the percentage of obscuration is maximum is known as the time of maximum eclipse.

Earth revolves around the Sun and Moon revolves around the Earth. Orbit of both Earth and Moon are not circular but elliptical and hence Earth comes near and goes farther away from Sun once in a year. Similarly, Moon also comes near and goes farther from Earth in approximately every 27.3 days. Because of this, we see the variation in their apparent size. In the process, on New Moon day if Moon is at closest approach and Sun, Moon, and Earth come in a straight line then we can expect a Total Solar Eclipse. Likewise, on New Moon day if Moon is at farthest point from Earth and Sun, Moon, and Earth come in a straight line, then we can expect an Annular Solar Eclipse.

Projection of Sun

With the help of a coordinator or team leader, make the arrangement of projecting the Sun as shown in picture below



After projecting the Sun, you will see the different phases of the Sun as shown in picture below:

Keep the track on your projected image of Sun and fill the observation table below.

Observation Table

Sr. No	Projected Image	Time
01		T1:
02		T2:
03		T3:

Calculation for time of maximum Annularity

From this table you can get the time of maximum annularity as below:

$$\text{Time of Maximum Annularity} = \frac{T1 + T3}{2}$$

ACTIVITY-2

Finding percentage of Annular Solar Eclipse

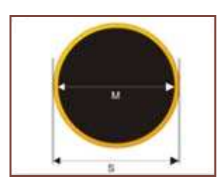
Projection of Sun

With the help of a coordinator or team leader, make the arrangement of projecting the Sun as shown in the picture above.

At the instant when you get the projected image of Sun as above, you are supposed to draw the Sun's and Moon's image on the screen using a pencil or a marker.

Observation Table

From the projected image of the Sun and Moon you are supposed to measure the diameter of Sun's and Moon's image and fill the table below:



Object	Diameter	Radius = Diameter/2
Sun's image		S =
Moon's image		M =

Calculation for finding the percentage of Annular Solar Eclipse

For finding the percentage of Annular Solar Eclipse, the following formulation can be used:

Percentage of Annular Solar Eclipse (P)=

$$\frac{\text{Area of Moon's image}}{\text{Area of Sun's image}} \times 100 \Rightarrow \frac{\pi M^2}{\pi S^2} \times 100$$

$$\Rightarrow P = \frac{M^2}{S^2} \times 100$$

Object	Diameter	Distance between mirror projector and projected image
Sun's image	S =	
Moon's image	M =	= L

Finding the angular size of Sun:

By using small angle formula, the angularsize of Sun can be calculated as,

$$\Theta_s = \frac{360^\circ}{2\pi}\frac{s}{L}$$

Finding the angular size of Moon:

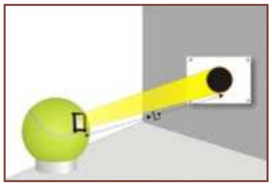
By using small angle formula, the angular size of Moon can be calculated as,

$$\Theta_M = \frac{360^\circ}{2\pi}\frac{M}{L}$$

ACTIVITY-3
Finding Angular size of Sun and Moon

Projection of Sun

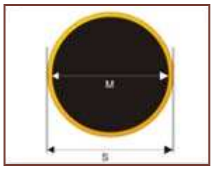
With the help of a coordinator or team leader, make the arrangement of projecting the Sun as shown in the picture in Activity -1



At the instant when you get the projected image of Sun as shown above, you are supposed to draw the Sun's and Moon's image on the screen either using pencil or a marker. In addition to this, you need to measure the distance between the mirror projector and the projected image of the Sun as shown above.

Observation Table

From projected images of the Sun and Moon you are supposed to measure the diameter of Sun's and Moon's image and fill the table below:



ACTIVITY-4
Observing Nature during the Solar Eclipse

Place of observation: ______________________

Duration of observation: ______________________

For conducting this activity, you need to take this observation sheet with you and need to go in the nature. You consistently need to observe nature and try to answer the following questions.

Observing sea waves

- Start observing sea waves and sea water level at the coastline a day before the eclipse. Note down the observation of sea waves and sea level after every hour. Write down your observation and comments.

Plant behaviour

- Did you find any plant which behaves abnormally during the eclipse period? If yes, can you note down your observations. (Hint: Try to look at the leaves and flowers of plants which require sunlight!)

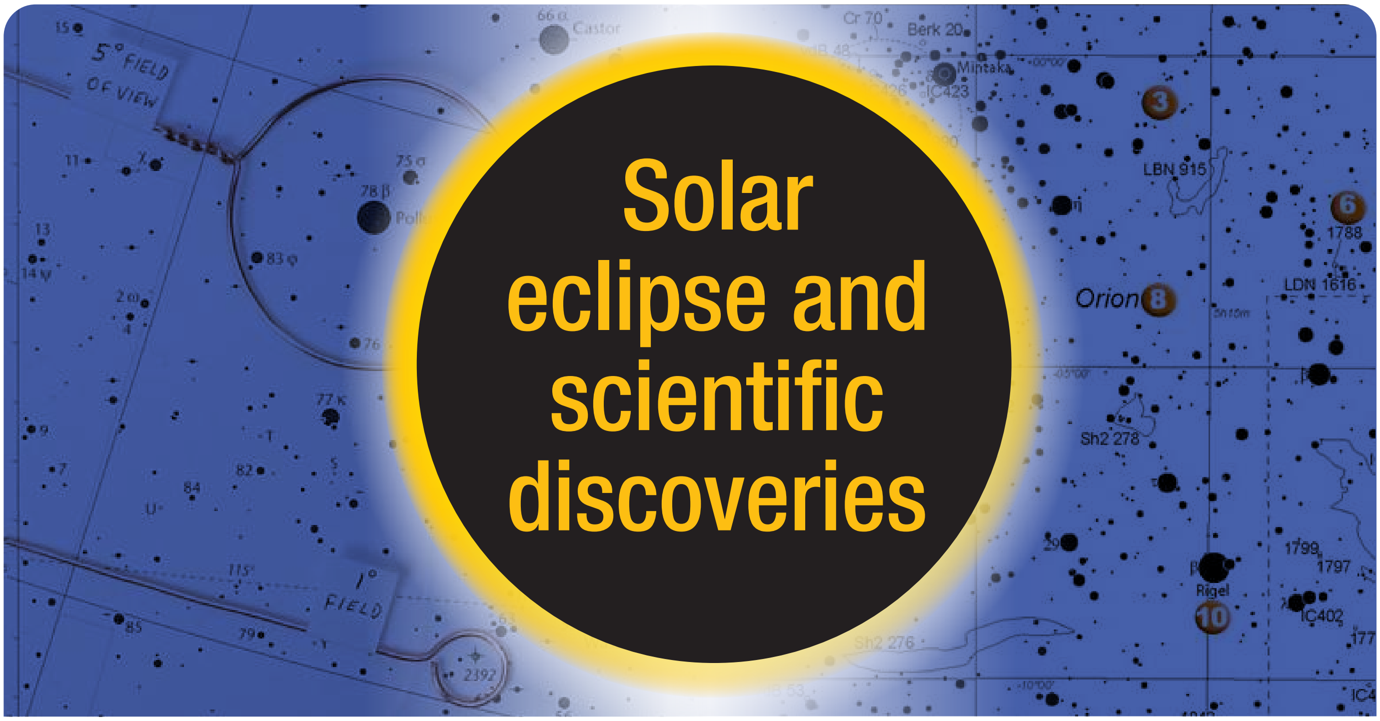
Animal behaviour

- Did you find any animal which behaves abnormally during the eclipse period? If yes, can you write the names of the animals and their abnormalities?

Bird behaviour

- Did you find any bird which behaves abnormally during the eclipse period? If yes, can you write the names of the birds and their abnormalities?

Dr B.K. Tyagi is Scientist 'F' in Vigyan Prasar.
Email: bktyagi@vigyanprasar.gov.in
Translation: Ram Sharan Das



Solar eclipse and scientific discoveries

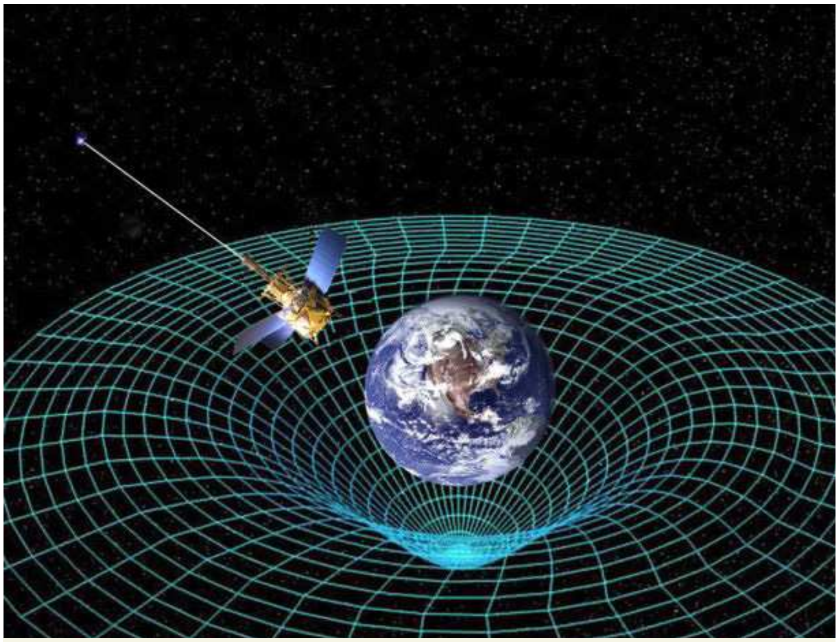
Rintu Nath

Solar eclipses have offered opportunities for ground-breaking observations that have helped science progress. In this article, among many scientific advances that were made during past solar eclipses, two notable observations are mentioned, namely experimental support for the general theory of relativity and the discovery of the element helium.

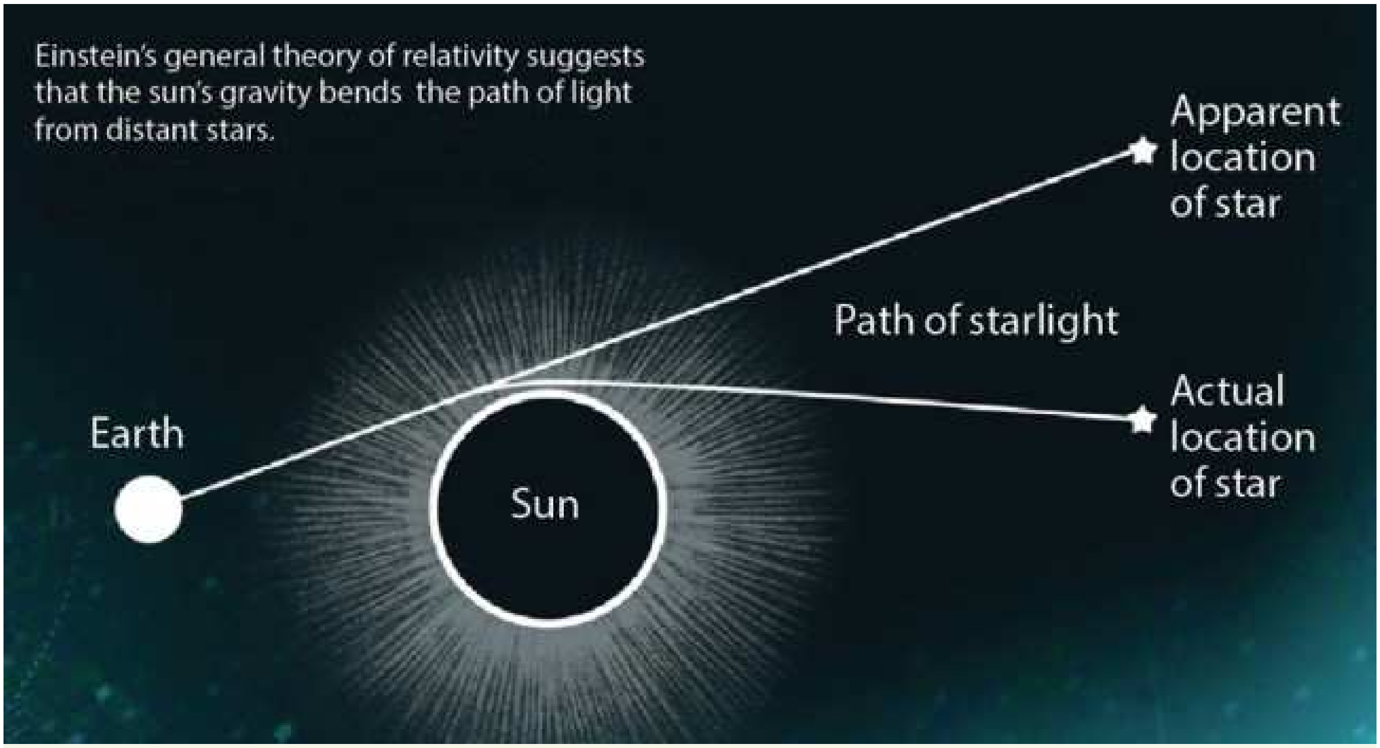
The general theory of relativity

In 1915, Elbert Einstein proposed the general theory of relativity. He explained gravity based on the way space could 'curve' in presence of mass and associated the force of gravity with the changing geometry of space-time. Newton had explained gravity as a force, pulling objects together. Einstein described gravity as a warping of time and space — a distortion in the fabric of the universe.

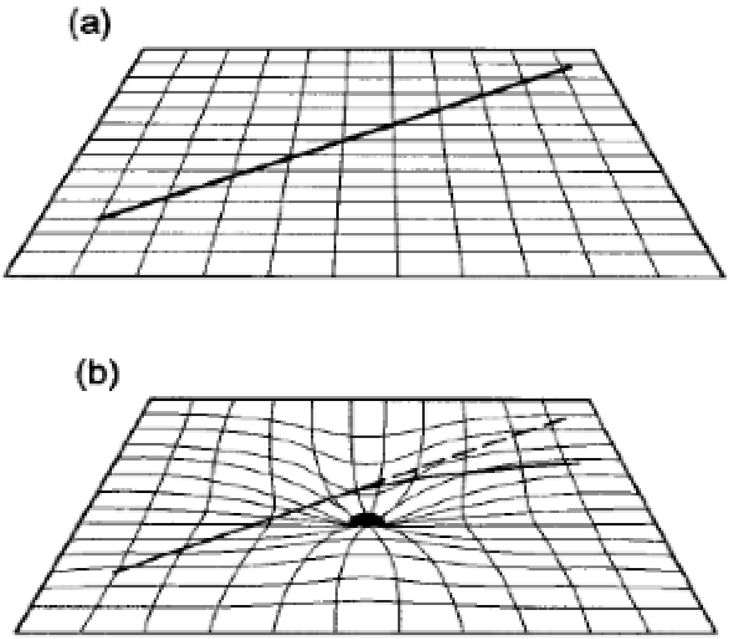
According to the general theory of relativity, light changes its path while travelling through the warped space-time. The more massive an object, the bigger the distortion, and the more its gravity can bend light. Einstein predicted that light rays from any distant star would bend while passing near any massive object like the Sun. As a result, the star would appear to be in a slightly different position in the sky during the day, compared to its position we see at night, when the Sun is in another part of the sky. Although according to Newton's gravitational theory too, light would experience gravitational attraction towards the Sun, the degree of the deviation was computed to be significantly higher according to Einstein's theory. It was evident that general relativity theory could be validated experimentally if the bending of light is established through observation. The only problem was that the Sun needed to be blocked from the view; otherwise, stars would not be visible during the day in the dazzling light of the Sun. A total solar eclipse was the only option to establish a positional shift. If the same star were observed in the night sky and also during the day during totality, comparison of the



An artist's concept of the curved space-time around Earth
Image credit: https://science.nasa.gov/



The general theory of relativity predicted bending of light.



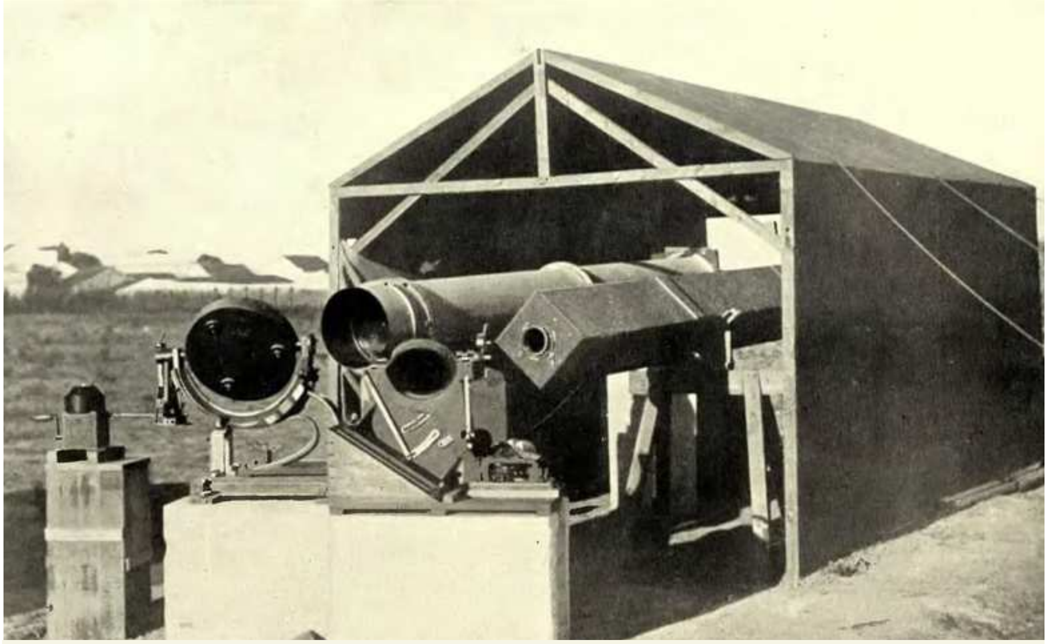
Curved space and the bending of light: (a) light travels in a straight line in the absence of any heavy object (b) Bending of light in the presence of any heavy object, like a planet or a star

Eddington's work

Sir Arthur Stanley Eddington was an English astronomer. In 1915, Einstein presented the general theory of relativity to the Prussian Academy of Sciences. It was wartime, and direct communication of scientific results between England and Germany was not possible. But Eddington was lucky to receive a copy of Einstein's papers from his Dutch friend Willem De Sitter. Eddington could understand the importance of the theory and wanted to validate it experimentally. In 1917, he presented a report to the Royal Astronomical Society and explained how observational validation could be carried out using measurements of star position during totality. Along with Eddington, another astronomer, Sir Frank Watson Dyson, also became interested in observational validation. Dyson and Eddington realised that the eclipse of 29 May 1919 could be the golden opportunity to test Einstein's theory. They also noted that at the time of eclipse, the Sun would

According to the general theory of relativity, light changes its path while travelling through the warped space-time. The more massive an object, the bigger the distortion, and the more its gravity can bend light. Einstein predicted that light rays from any distant star would bend while passing near any massive object like the Sun.

two observations could bring out the positional shift, if any. Of course, during an eclipse, the measurement needs to be taken from a spot where the totality is visible and at a time when the disc of the Sun is completely blocked and other stars are visible.



Eclipse instruments at Sobral
Image credit: C. Davidson - File: Eddington A. Space-Time and Gravitation. 1920.djvu, Public Domain: https://commons.wikimedia.org/w/index.php?curid=38550909

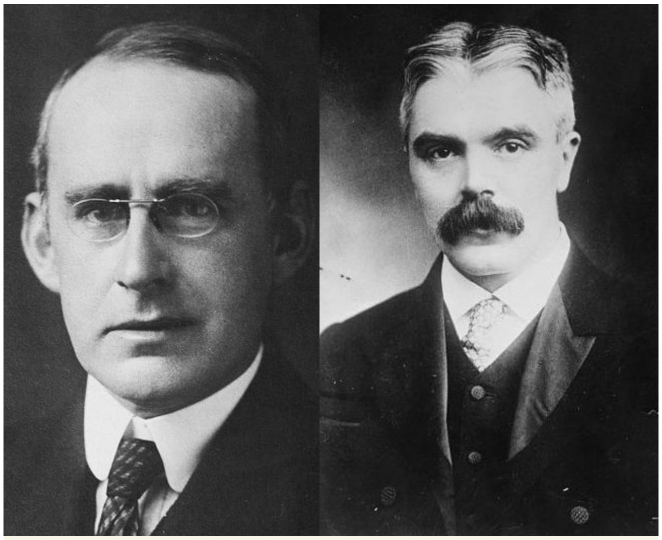
be in front of a prominent grouping of stars, known as the Hyades. At the time of totality, bright stars behind the Sun would be visible, whose positions could be measured and compared with the position of the same stars taken during the night at other times. They began to investigate possible observing sites. It was decided to send two expeditions, one led by Eddington and the other by Andrew Crommelin, who was an astronomer at the Royal Greenwich Observatory. Eddington and his team would travel to the island of Principe in West Africa, and Andrew Crommelin would travel to Sobral in northern Brazil.

Both expeditions had to overcome many hurdles. As the war was going on, it was not easy to get permission for such expeditions. After much persuasion, permission was obtained. However, both Eddington and Dyson encountered numerous technical problems. The expeditions needed specialised telescopes and photographic equipment. The availability of skilled human resources was difficult at wartime - they were either been conscripted or were engaged in war work. Both the expeditions were enormous – hence preparations were hectic. They had to start sailing at least three months before the eclipse date to ensure arrival in time and setting up camps and equipment.

On the day of the eclipse, heavy rain started in Principe, but near totality, the Sun began to appear dimly. Some photographic images could be taken through the cloud. Among several photographs, only two photos were considered useable. Sobral had better weather, but due to technical errors, photographs taken by the main telescope came out blurred. Fortunately, photographs taken by a backup 4-inch telescope came out well. These photographs became the most convincing proof in the final analysis.

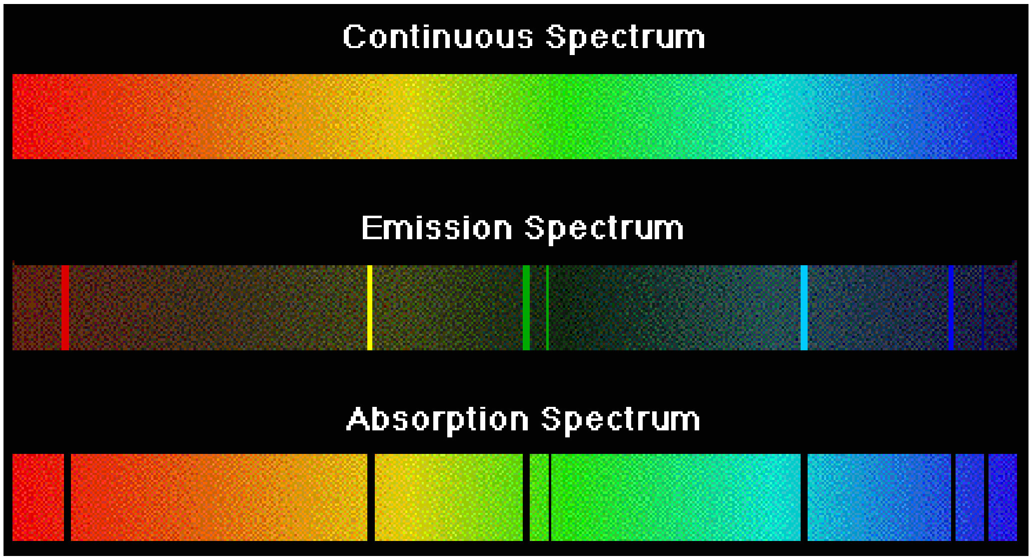
It took over five months to analyse data collected during the eclipse and reach any conclusion. Dyson and Eddington presented their findings at a special joint meeting of the Royal Astronomical Society and the Royal Society of London convened on 6 November 1919. Results were consistent with Einstein's prediction. Although several scientists criticised the findings and questioned the reliability of statistical evidence, J.J. Thomson, the Chair of the meeting, was convinced and commented: "This is the most important result obtained in connection with the theory of gravitation since Newton's day."

On the other hand, Einstein had no doubts. He expected consistent results from the English expeditions before the formal announcement. On 27 September 1919, he wrote a postcard to his mother: ". . . joyous news today. H.A. Lorentz telegraphed that the English expeditions have actually measured the deflection of starlight from the Sun". In 1922, another eclipse was viewed from Australia that yielded more convincing statistical data. Measurements of this kind during total solar eclipse using optical telescopes continued until 1950. With the advancements in astrophysics, these measurements are now possible to take in other frequencies of the electromagnetic spectrum, other than the visible range. However, the experiments of Dyson and Eddington during the total solar eclipse in 1919 are unique and very important in establishing the general theory of relativity.

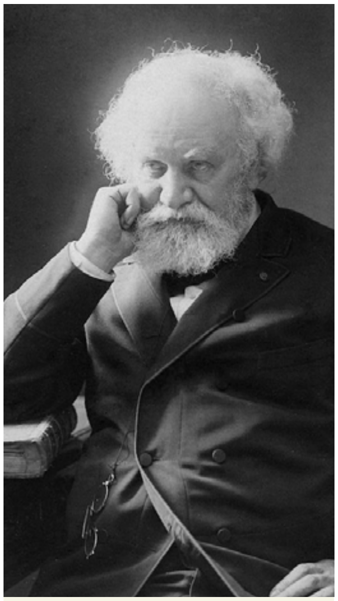


Arthur S. Eddington Frank W. Dyson

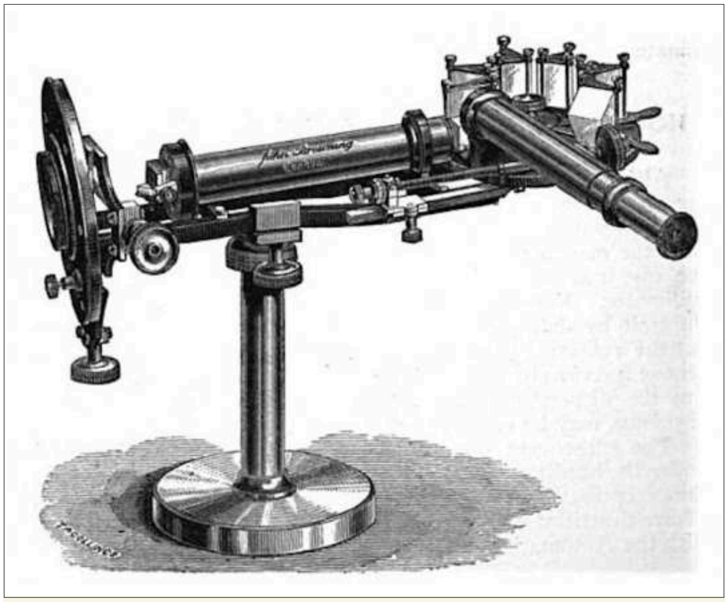
Discovery of helium



In mid-1800, many scientists were thrilled with a new instrument called a spectroscope. Similar in design to a telescope, the spectroscope worked like a prism, dispersing visible light into measurable wavelengths. It was observed that heating any element produced bright light; for example, sodium burns with a yellow flame. When one looks at the hot glowing gas through a spectroscope, a few discrete bright 'lines', called line emission spectrum, are observed. The same gas, when cooled and passed through background white light, absorbs light of precisely those colours that it would have itself radiated when hot. This time, one would see dark lines, called line absorption spectrum in a rainbow-coloured background. Every chemical element produces a unique spectrum, a sort of 'fingerprint', that confirms the presence of an element.



Pierre Janssen



Spectroscope used in the nineteenth century

Researchers started analysing the emission and absorption spectra of specific elements in the lab. Then they observed stars through spectroscopes and tried matching the spectra with known elements. Thus, it became possible to make out the chemical composition of stars across the galaxy.

French astronomer Pierre Janssen was very interested in spectroscopic analysis of visible light. He travelled across Europe and Asia to observe the night sky. He chased after eclipses, visiting Italy in February 1867 and then to Guntur, India, for the total solar eclipse of 18 August 1868. He camped in Guntur to watch the solar corona visible during a total solar eclipse. From the spectroscopic analysis, Janssen observed that the prominences were mostly made of super-hot hydrogen gas. But he also noticed that a yellow line in the spectrum did not match the wavelength of any known element.

Around the same time, one English amateur astronomer, Norman Lockyer, made a similar observation. His observation of Sun was, however, without the eclipse, using a special instrument called coronagraph that blocked out the light of the Sun so that researchers can glimpse the burning star's hot, thin, corona. Lockyer and English chemist Edward Frankland named the unknown element helios, after the Greek word for the Sun. Helium is the first and only element to be discovered and identified outside Earth.

For some time, helium was believed to exist only on the Sun and other stars. However, in 1882, Italian physicist Luigi Palmieri recorded helium's yellow spectral line in his data while analysing lava from Mount Vesuvius. Helium is probably best known today as the gas that fills birthday balloons. Helium is used in medical equipment (Magnetic Resonance Imaging) as well as in spacecraft and radiation monitors. It is also used in microscopes, airbags in cars, and in many physics experiments.

The author is Scientist 'F' in Vigyan Prasar.
Email: rnath@vigyanprasar.gov.in

Eclipses and Superstitions

Kinkini Dasgupta Misra

In the midst of a scorching bright day, when the Sun is at its highest, suddenly the brightness begins to fade and dusk starts falling on the land. The air gets cold and a sense of stillness fills the atmosphere and suddenly, in an instant, everything goes dark. You look up at the Sun, and it appears like a black disk. This is exactly what happens during a total solar eclipse, when at totality the Moon completely covers the Sun. For someone witnessing a total solar eclipse for the first time, it can be really frightening.

Mention of eclipses is found in almost all mythologies and literature of all ages and genres around the world. And most often they are projected as an embodiment of fear, terror and most precisely, collapse of the natural order of things.

Delving into the etymology of the Greek word "Eclipse", it means abandonment, which gets translated to the Sun abandoning the Earth. The embodiment of the eclipse turns out to be frog in Vietnamese, dragon in Chinese, dog in Korean, bear in American, and Rahu-a beheaded demonic figure that engulfs the Sun or the Moon in Indian mythology. Since the explanation of eclipses was not known in ancient times, most cultures believed that some demon or animal was trying to devour the obscured object.

The fear related to eclipses seems to be arising out of the natural instincts of humans. For many civilisations and cultures around the world, the Sun is the supreme life-giver-an inextinguishable source of light and life; anything that goes against this belief and is not under control of humans is seen as a terrible event or as an omen. Coincidental occurrences of some unfortunate events like death of King Henry in England in 1133 and the spread of Black death (caused due to bacillus *Yersinia pestis*) in Europe in 1345 had left the earthlings with no option but to believe in the apocalyptic power of eclipses.

For over 500 years, a recurring theme of the eclipse-related stories popular in many cultures was of a 'scientific' man taking advantage of the superstitious fear of the local people to manipulate them. In one of the most common versions of such stories, Christopher Columbus and his crew on their voyage attempt to terrify the local people of Jamaica with his godly powers to make the Moon disappear, unless they provided them with the food and supplies. As a sea voyager and an expert in reading sky-maps, Columbus was aware of a total lunar eclipse happening on 1 March 1504 and its exact time

Solar eclipses used to be seen as omens.

and duration. So, he could precisely predict when the Moon goes into the Earth's shadow.

An eclipse is a natural phenomenon involving the celestial bodies; however, there are many myths across many cultures about eclipses. In India, the description of eclipse is found in one of the oldest scriptures, the Rig Veda, which dates back to 1500BC, where the cause of eclipse or *grahanam* is attributed to a demon, named Svarbhanu, who trapped the Sun and made the Sun disappear, making the whole earth dark. This caused havoc among the gods and humans. The gods appealed to the Rishi Atri who was able to establish the eye of Surya in heaven once again and caused the magic of Svarbhanu to vanish, thus rescuing the Sun. Rishi Atri explained that a solar eclipse occurs when Svarbhanu (the Moon) comes between the Sun and the Earth.

The Puranas describe the story of Rahu, Ketu in a mystical way. It mentions Rahu devouring the Sun or the Moon and their escaping through his disconnected neck. As the geometry of Sun, Earth and Moon became clearer to the people and Indian astronomy adopted mathematical models of the motion of the heavenly bodies, Rahu and Ketu came to be associated with what are commonly known as eclipse nodes or the points where path of the Moon crosses the path of the Sun. The nodes are invisible, and so are the demons; the nodes change position in the sky, as the demons are pictured to do. It became possible by the astronomers to predict occurrence of the eclipses by tracking the movement of the nodes.

It is believed in India that eclipses occur when the Sun or the Moon is devoured by Rahu or Ketu and hence eclipses are considered as bad omens and get identified with traditional beliefs and superstitions. In AD 500, in India, Aryabhatta was the first to explain scientifically how lunar and solar eclipses occur, disregarding Rahu and Ketu. In the final section titled 'Gola' in his work *Aryabhatiyam*, he mentions that the Moon and the planets are visible by the reflected light of the Sun and the eclipses occur due to the shadows of one celestial object falling on the other. Aryabhata additionally gave numerical methods to make calculations about the duration of eclipses which were further refined by subsequent Indian scholars. These calculations were more precise than the techniques used by Europeans until the late18th century as substantiated by French Astronomer Guillane De Gentil in 1765.

Misleading interpretations

What concerns most scientists and science communicators are the misleading interpretations of these natural events. For almost all the cultures, everything goes out of balance with the universe during an eclipse and strange practices have been suggested to escape the wrath of eclipses. The extremes of such behaviours have led to the restrictions on activities that include refraining from eating, drinking and cooking during an eclipse and not witnessing these rare moments of the cosmos. Unfortunately, most of these myths and superstitions are engraved in our minds. Here we try to debunk some of the popular myths and superstitions related to eclipses with the possible scientific explanations.

Rahu's immortal head chasing the Sun and Moon, occasionally swallowing them, causing the eclipse

The most common misconception is that harmful radiations are emitted from the Sun during an eclipse, which is not based on scientific facts. As we know, the Earth constantly receives high-energy particles coming from the Sun in the form of light and heat that is essential for life to exist. A solar eclipse occurs when the Moon moves in front of the Sun as viewed from Earth, blocking the Sun's light and the shadow of the Moon

The fear related to eclipses seems to be arising out of the natural instincts of humans. For many civilisations and cultures around the world, the Sun is the supreme life-giver-an inextinguishable source of light and life; anything that goes against this belief and is not under control of humans is seen as a terrible event or as an omen.

Chinese dragon chasing the Sun

falls on the Earth. Therefore, there is no change of emission pattern released from the surface of the Sun during an eclipse.

A lunar eclipse occurs when the Earth's shadow falls on the Moon. During a lunar eclipse, the Earth is located between the Moon and the Sun thereby blocking the Sun's light from reaching the Moon. Since the reflected light from the eclipsed Moon is negligible as compared to the light of the Sun. there is no danger in watching a lunar eclipse with naked eye.

Another common misconception is that watching a solar eclipse can cause permanent blindness. This is only partly true because, looking at the Sun directly is harmful regardless of whether there is an eclipse or not. Scientists have studied the radiations from the Sun and stated that direct viewing of the solar eclipse without eye protection could result in blindness. However, during a total solar eclipse, it is safe to watch with the naked eye only during totality, when the Sun is fully blocked. During totality, when the Moon's disc completely covers the Sun, only the Sun's corona emits electromagnetic radiation. This radiation from Sun being so faint cannot cause blindness. However, it is advised not to look at the Sun before or after totality with naked eye because it can cause damage to the retina.

The restrictions on eating and drinking during eclipses have been ascribed to the supposed poisoning of food during an eclipse. The process of cooked food going bad within some hours is a natural and common event that we experience daily. But there is no real science to support the belief that food gets spoiled during an eclipse.

Another persistent belief in this modern age is that of solar eclipse causing birth defects in unborn foetuses or miscarriages in pregnant women. The belief also traces its origin to some unfortunate events and stories of the past. The suddenness of the darkness that descends at totality can be frightening enough to cause a pregnant woman to abort; therefore there is no scientific evidence that eclipses per se harm pregnant women or their unborn babies.

Scientists have stated that there is no scientific basis behind these myths and superstitions and that eclipses have no harmful effects on us. The government and many scientific organisations, engaged with science popularisation activities including Vigyan Prasar have encouraged people to come out and witness the magnificent natural phenomenon using certified filters and eclipse glasses.

Vigyan Prasar organises regular awareness programmes to popularise astronomy and dispel the myths among students, teachers and general masses to inculcate scientific temper. It also organises public viewing camps and activities during solar and lunar eclipses.

The author is Scientist 'F' in Vigyan Prasar.
Email: kdgm@vigyanprasar.gov.in

The Sun: Our Star

Kapil Tripathi

The Sun, which binds all the planets of the solar system by its gravitational force, is a moderate-sized star. It is the nearest star from Earth and fulfils most of the requirements of light and heat needed to sustain life on our planet.

The Sun emits a steady stream of charged particles called solar wind that passes by Earth and the other planets creating what is known as 'space weather', which affects the Earth in many ways. At its worst, it can even damage satellites and cause electrical blackouts on Earth! To understand more about it, let us know more about the Sun.

Physical properties of the Sun

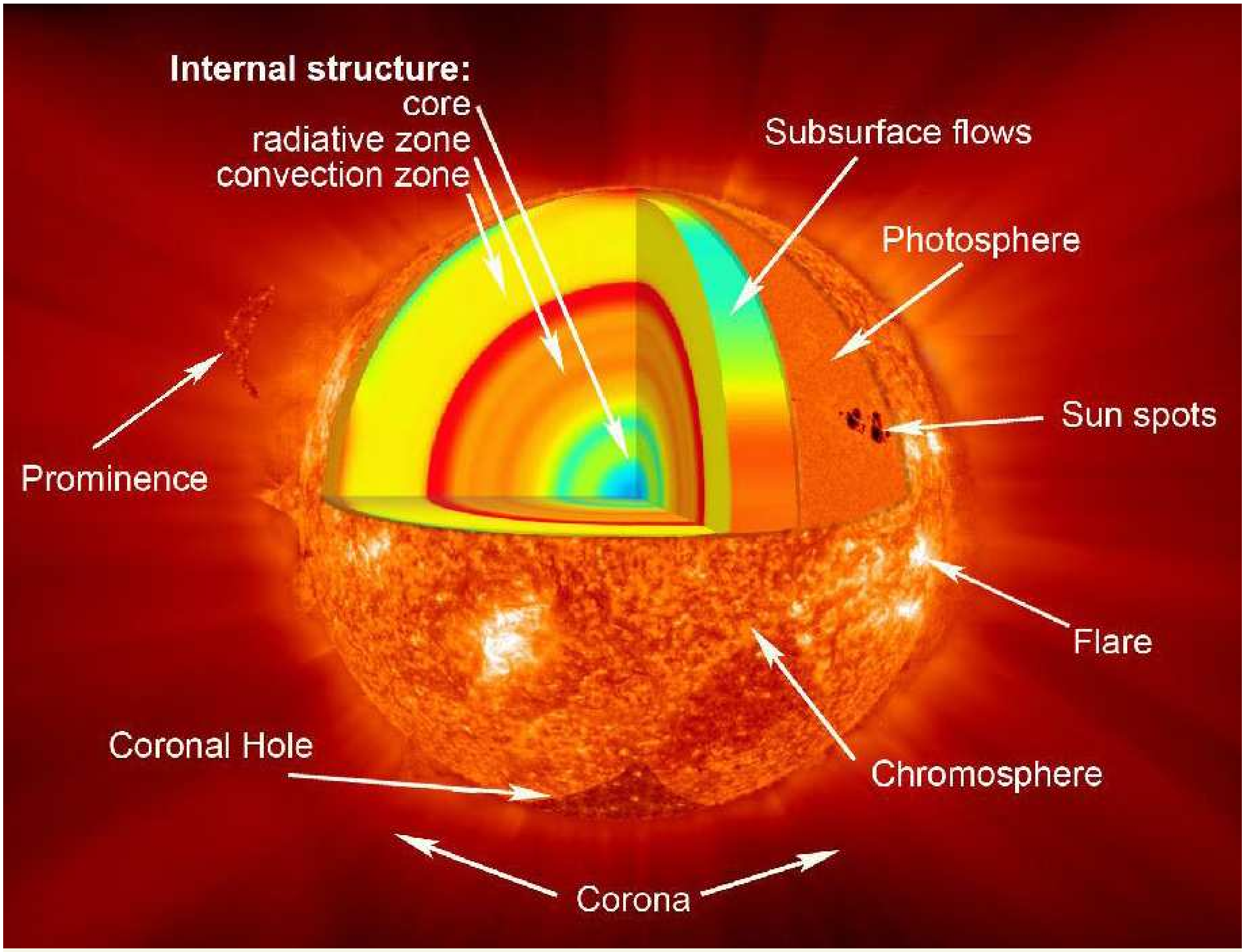
The Sun is a star and does not have a solid structure. Rather it is a hot, gaseous body with a core temperature of around 15,000,000°C and a surface temperature of about 5,600°C. Due to the extremely high temperature, no matter on Sun can exist in solid or liquid state. It can exist only as plasma – a gas of ions. The mass of the Sun is estimated to be about 2×10^{30} kg, which is about 3,33,000 times the mass of Earth.

Hydrogen and helium are the most abundant elements found on the Sun, making up about 98 per cent of its mass. The remaining amount is made up of oxygen, carbon, and other elements. The helium on the Sun was discovered in 1868, almost 27 years before it was found on Earth (1895). Helium on the Sun was detected with the help of a spectroscope from Guntur (Andhra Pradesh) during the Total Solar Eclipse on 18 August 1868. The Sun is not stationary but rotates around its axis once in about 27 days. Being a gaseous body, different parts of the Sun revolve at different speeds. Its rotation period at the equator is around 25 days, which goes up to about 38 days near the poles.

The internal structure of the Sun

The temperature at the central part of the Sun is exceptionally high. At this high temperature, the nuclei of hydrogen start turning into helium nuclei through a process called thermonuclear reaction, which releases tremendous amounts of energy. In the process, around 42.50 lakh tons of hydrogen is converted into helium per second. This process is mainly responsible for producing energy in the Sun or any other star.

The core of the Sun is surrounded by six concentric spherical layers called radiative zone, convection zone, photosphere, chromosphere, transition region, and corona, respectively. From Earth we can see only the outer layers, namely photosphere, chromosphere, and corona. Sunlight comes mainly from the photosphere; the chromosphere and the solar corona are normally not visible. But during a total



Courtesy: Nasa.gov

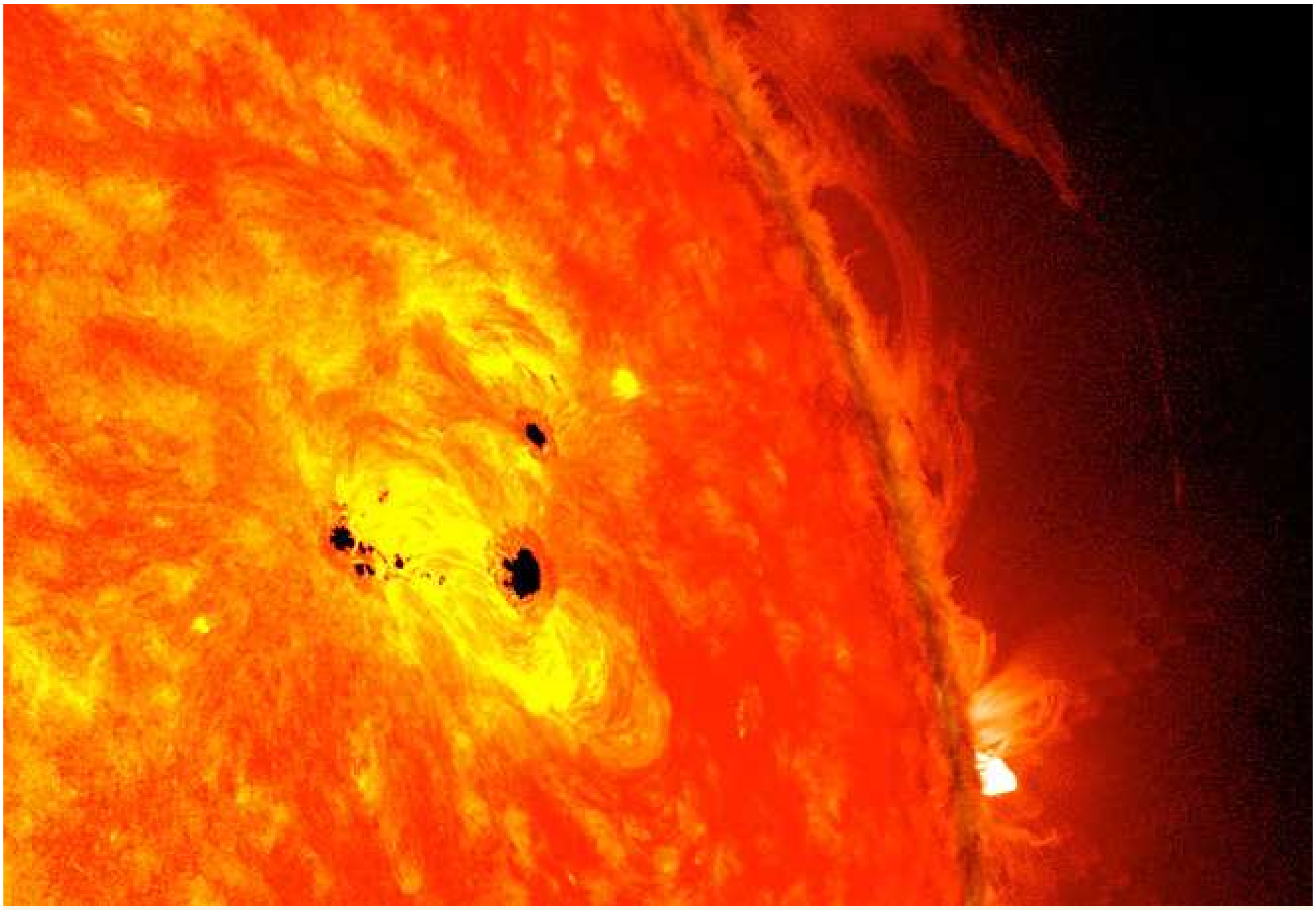
solar eclipse, when the Moon covers the photosphere, the chromosphere can be seen as a red rim around the Sun and the corona appears as a faint halo around the blackened Sun.

The temperature in the Sun does not vary in a regular manner. As we move towards the surface of the Sun from the core, the temperature decreases from 15,000,000°C to 3,727°C in the chromosphere. Thereafter the temperature rises again and reaches up to 1,800,000°C in the corona. The region between the chromosphere and corona, where the temperature rises again, is called the transition zone. The reason for this sudden increase in temperature is still a subject of investigation. Some researchers believe that the photosphere heats the corona from the non-thermal source of energy stored in its magnetic fields. This may involve two mechanisms: one is the current generated by the changing magnetic field and the other is magnetohydrodynamic waves.

The Sun occasionally shows dark spots on its surface called sunspots. These spots are not really dark but appear dark because they are cooler than the surroundings. Regions of the Sun near high magnetic fields get cooler as compared to the other areas. Therefore, they appear dark against the bright background giving the appearance of a spot. Every eleven years, the sunspot activity reaches the maximum, and a large number of sunspots are noticed on the Sun's surface. The magnetic field of the Sun and the nature of sunspots are not yet fully understood.

The hydrogen present in the Sun gets consumed every moment in the formation of helium. When the store of hydrogen gets exhausted, there will be no fusion and the Sun

In addition to light and heat, the Sun gives out electromagnetic radiation of other wavelengths. These wavelengths include radio waves, ultraviolet rays, high energy X-rays, etc. The Sun also emits streams of charged particles commonly known as solar wind.



An active region on the sun with dark sunspots. *Image credit: NASA/SDO/AIA/HMI/Goddard Space Flight Center*

will stop producing energy. At that stage, the Sun will start to swell, cool and will expand to become a huge red giant. At that time, the size of the Sun will increase by about two and a half times that of today, engulfing planets up to Venus and maybe even Earth. After that it will start shrinking again, turning atoms of helium into more massive atoms like carbon and oxygen. But with Sun's mass, the process cannot go any further and a stage will come when all reactions will stop. The newly formed elements will collect at the centre of the Sun, which will then shed most of its red giant envelope – creating a planetary nebula and leave behind a hot white dwarf star as remnant. The Sun has existed for about five billion years and will last for another five billion years.

Space weather caused by the Sun

In addition to light and heat, the Sun gives out electromagnetic radiation of other wavelengths. These wavelengths include radio waves, ultraviolet rays, high energy X-rays, etc. The Sun also emits streams of charged particles commonly known as solar wind. Explosive events like solar flares and coronal mass ejections (CMEs) cause violent release of gas and magnetic fields at the Sun's surface, which send solar storms into space. Some of the energetic particles of these storms are deflected by the Earth's magnetosphere. When the energetic particles collide with the atoms in the Earth's upper atmosphere, it creates a natural display of light called aurora. Auroras are the most visible effect of the Sun's activity on Earth's atmosphere. To observe space weather events, scientists use different instruments like land- and space-based sensors and imaging systems to view the activity at various depths in the solar atmosphere.

Observation of the Sun

Events like solar eclipse are very rare. They are natural phenomena which are well understood scientifically. Many important scientific observations related to the Sun can only be carried out during such occurrence. On normal days, many features and phenomena of the Sun cannot be studied due to the brilliance and high luminosity of the Sun. During a solar eclipse, when the Sun is covered by the Moon, the outer layers of the Sun become visible. It gives a window of opportunity to the scientists to study more about the Sun. Today, we know several important facts about the Sun but many phenomena like physical and dynamic processes inside the solar corona, the sharp increase in temperature in the corona region, the magnetic field of the Sun and sunspot, etc., are yet to be understood completely.

The author is Scientist 'F' in Vigyan Prasar.
Email: kapil@vigyanprasar.gov.in

Solar Eclipse and Safety of the Eye

K.B. Bhushan

We will have an opportunity to watch an Annular Solar Eclipse on 21 June 2020, mainly from the northern states like Rajasthan, Haryana, and Uttarakhand. The path of annularity will pass through these states, though a partial eclipse will be visible from other parts of India including the southern states like Tamil Nadu. It is an excellent opportunity for all of us to witness this celestial drama of light and darkness. After 21 June, the next solar eclipse will be seen from Indian soil only after a decade. So better be ready to watch this annular eclipse, though in a safe way.

Looking at Sun during an eclipse or otherwise is dangerous. The safest way is to watch the eclipse indirectly, by projecting the image of the Sun using a small mirror or telescope (both Galilean and Newtonian) projection method. But watching a solar eclipse directly using a certified filter is undoubtedly a lifetime experience. However, the intrinsic human curiosity has forced many to observe solar eclipses without any safeguard or by other unsafe means. Lack of scientific information on safe viewing of an eclipse may cause serious injury to the eyes (also known as eclipse blindness), which may be temporary or permanent. It is also known as solar retinitis in the medical terminology. Careless viewing of solar eclipses has brought to light many such harmful effects. It is often believed that during an eclipse the Moon blocks enough of Sun's light, making it safe to look at directly. However, except during totality, when the entire Sun is blocked out, the level of light and heat radiation coming from the Sun remains dangerously high.

There are several factors responsible for the damage caused to the eyes by unprotected observation of the Sun. To get an insight into how solar radiation during a solar eclipse can affect the eyes, we need to have a look at the structure of the eye.

Eye anatomy and the process of vision

Before we see anything, several small processes occur at an incredibly high speed. In order for us humans to see an object, light must fall on it to illuminate it. The object then automatically reflects part of the incident light which then enters our eyes when we look at it. The light first passes through the transparent cornea in the front part of our eye and enters the pupil, the black "hole" in the middle of the eye.

> **Careless viewing of solar eclipses has brought to light many harmful effects. It is often believed that during an eclipse the Moon blocks enough of Sun's light, making it safe to look at directly. However, except during totality, when the entire Sun is blocked out, the level of light and heat radiation coming from the Sun remains dangerously high.**

The pupil dilates or contracts by the action of the iris, which surrounds it, to control how much light goes into the eye. When it is dark, the pupil dilates so that more light can enter. When it is very bright, it contracts and makes itself as small as possible so that too much light does not get through. Iris is the coloured circular membrane around the pupil which decides the eye colour. It is a muscle ring that helps the pupil to shrink and enlarge.

After crossing the pupil, the light hits the lens, which forms an inverted image on the retina at the back of the eye. All information contained in the image is collected there. The retina is lined with millions of tiny photoreceptors called rods and cones, which turn the light signal into electrical signal. The rods are sensitive to low light and can only perceive in black and white, while the cones can perceive in colour but can work only in bright light. This is the reason why we only see everything a bit unsharp and grey coloured in low light, but sharp and colourful in bright light.

The information collected by the rods and cones is passed on to the optic nerve as electrical signal. This brings them directly to the brain where it is evaluated and put together to form a real picture, making us 'see' the object before us the right way round. The eyelids protect our eyes from too much brightness and from dust particles and other objects. The tear glands produce fluid that keep the eyes moist.

The power of Sun

The Sun is a source of enormous energy. Every square metre of the Sun's surface emits about as much energy as required to light up a million light bulbs. Only a fraction of this enormous energy reaches Earth. The energy available from solar radiation at the Earth's surface is about 1.36 kilowatt/m^2. When we look at the Sun directly, the pupil contracts to approximately 2 mm diameter, making approximately 3% of the energy enter the eye.

Why is it unsafe to observe an eclipse directly?

One thing must be made clear here. Whether there is an eclipse or not, looking at the Sun directly without protection is unsafe and dangerous for the following reasons.

The size of the image of the Sun at the retina is of the order of 0.2 mm. Hence the energy available at the retina is concentrated approximately in an area of a circle with a radius of 0.1 mm.

Area of pupil (radius 1mm) = 0.03 cm^2

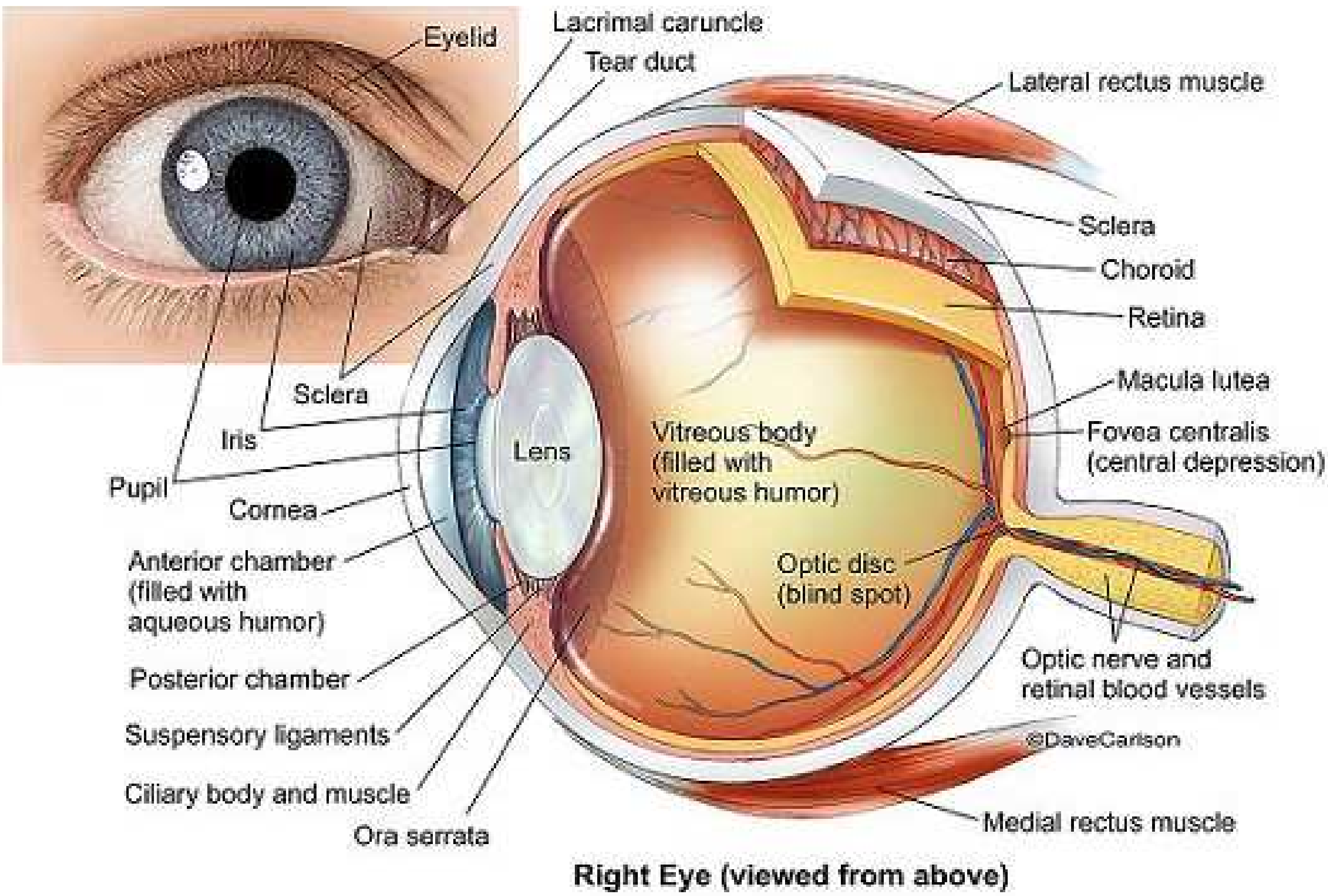
Thus, energy incident at the pupil

$= 1.36 \times 10^{-4} \times 0.03$ kw

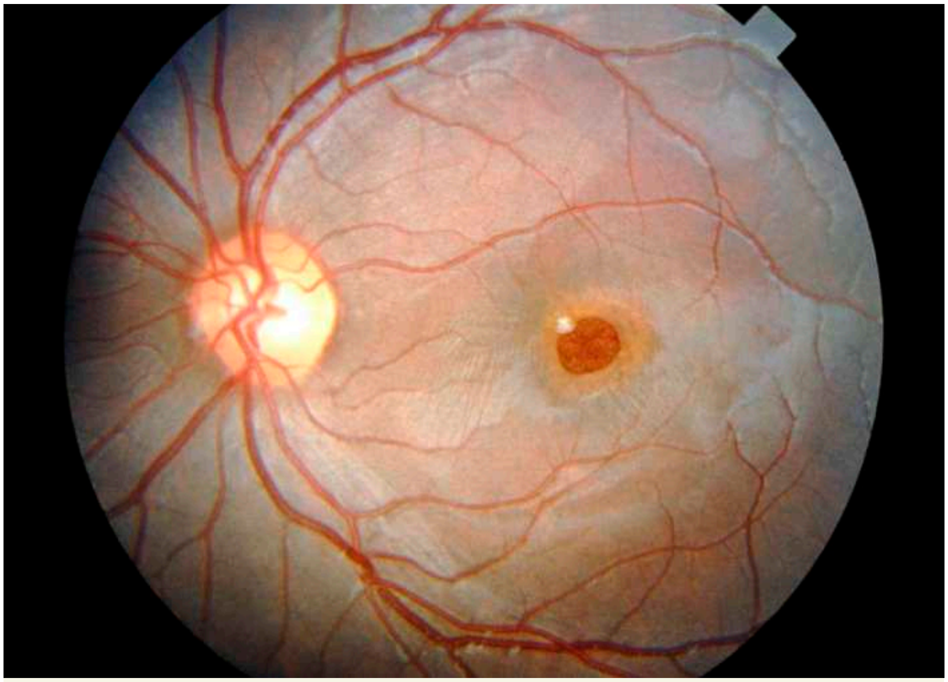
$= 0.040 \times 10^{-4}$ kw

$= 4 \times 10^{-6}$ kw

Seventy per cent of this energy is available at the retina; which



Basic structure of the eye
(Source:http://www.vision-and-eye-health.com/eye-anatomy.html)



The effects of solar retinopathy on the eye
(Source: Sue Ford/Science Photo Library)

means energy incident at retina

$= 4 \times 0.70 \times 10^{-6}$ kw/cm^2

$= 3 \times 10^{-6}$ kw

The diameter of the image being0.2 mm, the energy absorbed in the retina concentrated in an area of 0.03 mm^{2}will be equal to 0.03×10^{-2}cm^2 = 3×10^{-4} cm^2.

Hence the concentration of solar energy (heat and light) in the area of the image will be equal to $3 \times 10^{-6}/3 \times 10^{-4} = 10^{-2}$ kw/cm^{2}or 100 kw/m^2. This is about 74 times the solar energy incident on Earth per square metre (1.36 kw/m^2). So, it is no wonder that it can cause retinal burns even if viewed for only a few seconds!

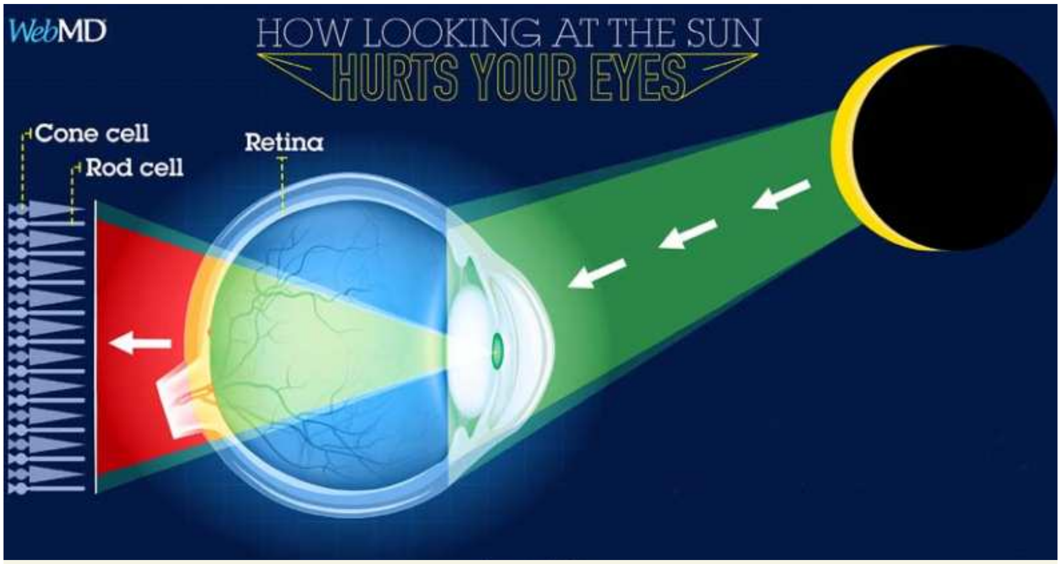
We all know how sunlight can start a fire when focussed through a magnifying glass. The Sun can do the same thing to your retina. Sometimes, following subliminal exposure, only temporary symptoms appear. But following severe exposure, a destructive burn may cause permanent damage, which is a serious matter when the macula is involved. A solar chorioretinal burn (sun blindness or photoretinitis) is an injury of this type.

In most cases, nothing abnormal is noticed immediately except for the dazzling sensation. However, a diffuse cloud is seen floating before the eyes shortly afterwards, usually associated with irritating after-images, photophobia (fear of light), and occasionally photopsia (light flashes), as well as chromatopsia (colour disturbance). After 24 hours, this diffuse cloud contracts into a dense scotoma (a blind spot or area of depressed vision) which may last for weeks or months or even permanently. Intense solar radiations can hurt or destroy the retina rod and cone cells causing damage to your inner eye. So, do not take chances. Rush to an ophthalmologist in case of any symptoms mentioned earlier.

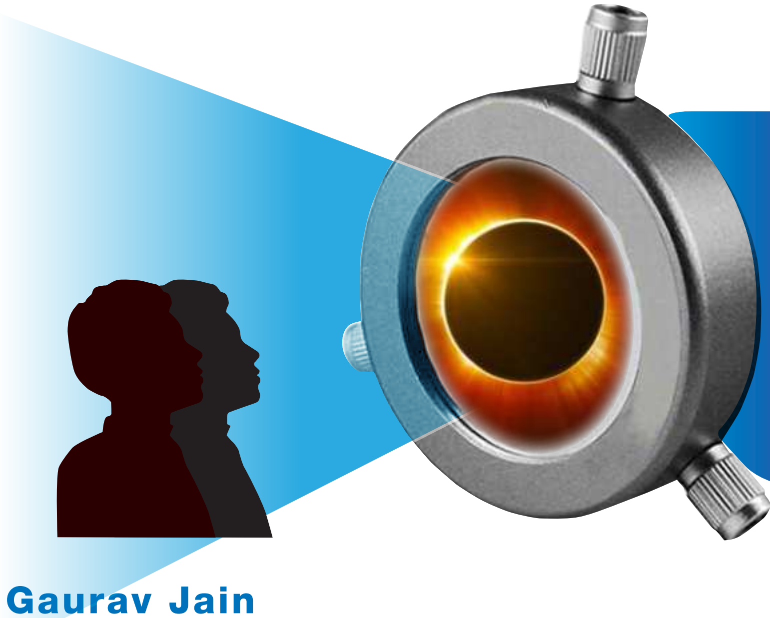
Observe solar eclipse safely

Do not attempt to observe the Sun directly, even during the partial (or annular) phases of any eclipse with the naked eye. Unless appropriate filters are used, it may result in permanent eye damage or even blindness! It is, therefore, advisable to follow certain guidelines for safe viewing of a solar eclipse (partial or annular). The fact that the Sun appears darker in a filter such as smoked glass, sunglasses, coloured film, photographic neutral density filters, etc., it does not guarantee that your eyes would be safe. Damage to the eyes comes predominantly from invisible infrared wavelengths. Avoid all unnecessary risks.

Dr K.B. Bhushan is Scientist 'D' in Vigyan Prasar.
Email: bhushan@vigyanprasar.gov.in



Looking at the Sun during eclipse hurts your eyes.
(Source: https://www.webmd.com/eye-health/news/20170809/during-eclipse-your-eye-can-scorch)



Safe methods of observing solar eclipse

Gaurav Jain

Imagine yourself standing outside your house in the afternoon hours and suddenly it gets dark, stars start appearing in the sky, the temperature drops and then after a few minutes the Sun reappears again, and everything returns back to normal. This is a typical sequence of events that follow in course of a total solar eclipse. In fact, observing a total solar eclipse can be an unforgettable experience. A solar eclipse occurs when the Moon comes between the Sun and the Earth. Although observing a solar eclipse may be exciting, remember, it is never advisable to observe a solar eclipse directly with naked eyes or with a telescope or similar optical device. If you don't take proper care while looking at Sun directly, it may damage your eyes. We all know that if we focus sunlight on dry leaves with the help of a magnifying glass they catch fire. Your eyes also have a similar lens and when you look at the Sun with naked eyes, the same thing happens to your retina (the back potion of your eye) – it gets burnt, causing reduced vision or even blindness. And as your eyes don't have any pain receptor you would not even know about it.

The solar eclipse of 21 June 2020 is not a total solar eclipse; the Moon will not completely cover the Sun but will leave a bright ring or 'annulus' around it. That is why it is called an annular eclipse. Unlike a total eclipse where it is safe to watch the Sun at totality, it is not safe to watch an annular eclipse at any time because even at the time of annularity the Sun will be bright enough to damage the eye.

A solar eclipse can be observed safely only if proper precautions are taken. Described here are some safe direct and indirect methods of observing the Sun. Following these methods, you can feel the thrill of watching the eclipse.

Direct methods of observing the solar eclipse safely

Solar filter goggles

Solar filter goggles offer the easiest and most convenient means of observing a solar eclipse. These goggles are made using approved solar filters in a cardboard frame. It is worn just like ordinary goggles. In case you normally wear spectacles you can mount your solar filter goggles over them. Even while using filters the Sun should not be observed consistently for a long time; look at the Sun through the filters for a while and then look at something else for some time.

Solar filter goggles *(Credit: https://astronomy.wonderhowto.com/how-to/red-ring-fire-heres-watch-sundays-annular-solar-eclipse-and-not-get-blinded-0135101/)*

Welder's goggles

To look at the Sun directly, a number 14 welder's goggles is also a safe alternative. Compared to other devices used for looking at the Sun it can be more easily obtained, but is costlier than the solar filter goggles and the Sun appears of unnatural green colour when we see through it. It should be used only as an alternative.

Welder's glass *(Credit: https://astronomy.wonderhowto.com/how-to/red-ring-fire-heres-watch-sundays-annular-solar-eclipse-and-not-get-blinded-0135101/)*

Solar filter for camera and telescope

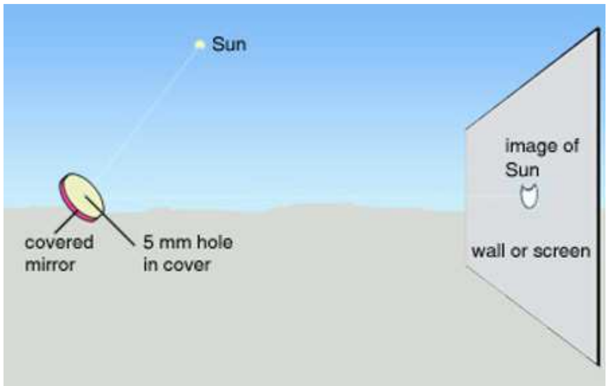
Telescope and camera companies make specially designed solar filters. By mounting these filters on the telescope the Sun can be observed directly. These solar filters are a bit costlier, but they are favoured, because, they are available in different shades. For example, through chromium filter the Sun appears in orange colour, whereas it appears blue-grey when observed through aluminated mylar. You can mount these filters on telescopes easily and observe the Sun directly.

Solar filter for camera or telescope *(Credit: https://astronomy.wonderhowto.com/how-to/red-ring-fire-heres-watch-sundays-annular-solar-eclipse-and-not-get-blinded-0135101/)*

Indirect methods for observing solar eclipse safely

Mirror method

The mirror method is a good and simple method of observing solar eclipse safely. What you need is just a piece of circular mirror (about 7.5 cm radius) which you can easily get from a local stationary shop. Throw the image of the Sun on a wall at least one metre away. If you like you can stick the mirror on a ball and keeping it in a bowl filled with sand to form the image of the Sun on a wall or a screen. This is the easiest and the safest way of watching a solar eclipse.

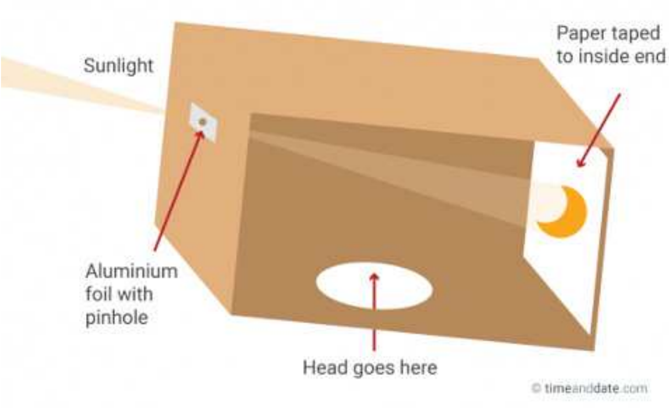


Mirror method *(Credit:https://www.popastro.com/main_spa1/using-a-mirror-to-view-a-partial-eclipse/)*

Remember, seeing Sun directly through pinhole maybe dangerous; therefore, while using a pinhole camera the Sun should remain at your back. The sunlight from the pinhole of the cardboard passes over your shoulders and forms the inverted image of the Sun on the cardboard screen.

Pin hole projection camera

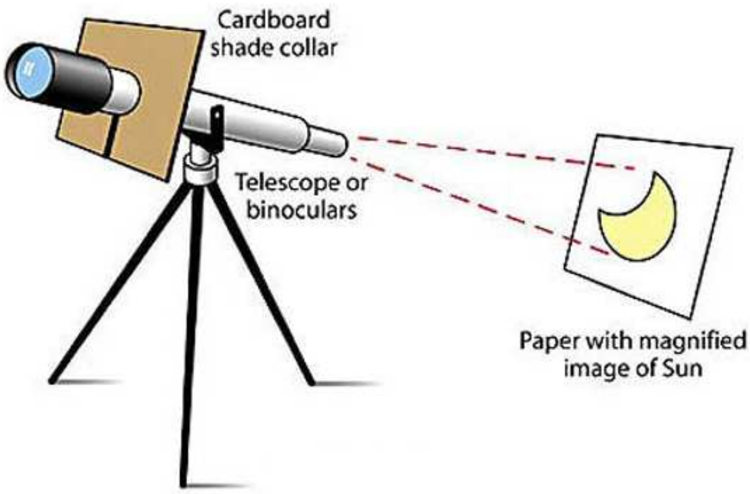
If you do not have filter goggles or welder's glass, then you can make your own pinhole camera to see the image of the Sun. Use a cardboard box to make your pinhole projection camera. You may also use two white cardboard pieces to make the projection. Make a small hole (pinhole) in a piece of cardboard and let sunlight fall on the second piece of cardboard through it; this will form an inverted image of the Sun on the second cardboard. To increase the size of the image, increase the distance between the two cardboards and to increase the brightness of the image, bring the two cardboards closer. While making hole in the cardboard, be cautious to keep its size small, or else, you will see the spread of sunlight only in place of the image of the Sun. Remember, seeing Sun directly through pinhole maybe dangerous; therefore, while using a pinhole camera the Sun should remain at your back. The sunlight from the pinhole of the cardboard passes over your shoulders and forms the inverted image of the Sun on the cardboard screen.



Pinhole projection camera *(Credit: https://www.timeanddate.com/eclipse/box-pinhole-projector.html)*

Projection with a telescope

A small, inexpensive telescope, having no solar filter, can be used to project the image of the Sun on a screen. Turn the telescope till you get the image of the Sun on the screen. Then adjust the distance of the screen to bring the image in focus. Now turn the focussing knob to get a clear sharp image. Extra sunlight coming from the surroundings can be stopped and contrast can be enhanced by placing a cardboard in front of the telescope. Obviously, looking at the Sun directly through a



Projection with a telescope
(Credit: https://eclipse.aas.org/eye-safety/projection)

telescope is dangerous. To project the image of the Sun a small telescope (less than 80mm) should be used, as large amount of energy collected by it may harm the inner parts of the telescope. The image formed by a telescope will be large, intense and bright as compared to the image formed by a pinhole camera as the telescope collects more light and focusses it better.

We can use a natural phenomenon like solar eclipse to demonstrate how the laws of motion and the mathematics of orbital motion help us predict eclipses. Use of instruments like pinhole camera and telescope also help us to understand the laws of optics and theories associated with it. The rise and fall in the intensity of light during the solar eclipse also demonstrate the principles of radiometry and photometry while biology tells us about the change in the behaviour of animals and plants during the eclipse and its effect on their behaviour. In fact, many scientists were inspired to opt for science as their carrier after observing solar eclipse.

The author is a Junior Scientific Officer in Vigyan Prasar.
Email: gaurav@vigyanprasar.gov.in
Translation: Ram Sharan Das

DO'S AND DON'TS FOR OBSERVING A SOLAR ECLIPSE

DO'S	DON'TS
It is best to view reflected or projected image of the Sun.	Don't attempt to observe the partial or annular phase of any solar eclipse with naked eyes.
Project the image of the Sun on a shaded wall through a hole.	Never look at the Sun through a telescope or binoculars. (In fact, you don't need these instruments to watch a solar eclipse.)
A small mirror covered with a piece of paper having a circular hole of diameter (1-2 cm) can be used to project the image of the Sun on a shaded wall.	Don't use any filter that simply reduces the visible intensity of the Sun. Fifty-two percent of the Sun's rays are in the infrared region of the spectrum. This invisible infrared energy predominantly causes damage to the eye.
A small telescope or binoculars can be used to project the image of the Sun on a white card/screen/wall. If binoculars or telescope has any plastic parts, take necessary precautions to protect them from heating and melting by focussed sunlight.	Don't use smoked glass, colour film, sunglasses, non-silvered black & white film, photographic neutral density filters, and polarizing filters. They are not safe.
Direct viewing of the partially eclipsed Sun should be done only using a scientifically tested filter certified to be safe. A dark welder's glass (No. 14) is ideal. Use only one of your eyes to view the eclipse. In all cases, please examine the filter before use. A filter with pinholes/ scratches must not be used. Don't touch, fold or wipe the film with your fingers under any circumstances. Any scratch or fold on the film would render it unsafe for viewing the eclipsed Sun.	Don't use solar filters normally available with eyepieces of inexpensive telescopes.
During the eclipse, look at the Sun intermittently through safe filters.	Don't look at a reflection of the Sun from coloured water.

SHRI KRISHNA JOSHI
(1935-2020)

Dinesh K Aswal

Shri Krishna Joshi, popularly known as Professor S K Joshi, one of the best science leaders and condensed matter physicists of this country left to his heavenly abode on 15 May 2020 at the age of 86 at his residence in Gurugram, Haryana. It was only a few days ago before the corona lock-down started in the country in the month of March, I visited him and had a long chat with him about his health. At that time, he was suffering from cancer in his thigh and was confined to bed. He had his usual charismatic smile beneath which the deep pain of the illness was evident. In several hours' long discussion, he narrated his journey from a small village of Uttarakhand to raising the position of Director General of Council for Scientific and Industrial Research, (DG, CSIR), New Delhi. Today 16 May, 2020 the present DG Dr. Sekhar Mande and myself joined his last journey and remembered his immense contributions to the Indian science and technology. His demise is truly end of an era.

Professor S K Joshi was born on 6 June 1935 in a small village of Anarpa in Kumaun, Uttarakhand, India. During his schooling days, he used to walk everyday several kilometers of tough terrains of Himalaya to reach his school. For his higher education, he moved to Allahabad University and obtained BSc and MSc (Physics) degrees, both with first class. In 1957, being the Gold medalist in MSc, he was offered the position of Lecturer in Physics at Allahabad University. In parallel, he started his research work in measurement of diffuse X-ray scattering from organic crystals for his doctoral degree with K Banerjee and received his PhD degree in 1962. In 1965 he was offered a position of Visiting Lecturer by University of California, Riverside, USA. After working two years in USA, he returned India and joined as a Professor of Physics, at a pristine age of 32 years, at the University of Roorkee (now IIT Roorkee). His experimental work during his PhD and his experience in US got him seriously interested in theoretical studies of lattice vibrations, i.e., phonons in metals and insulators. In metals, the frequencies of phonons depend on the response of conduction electrons to ion motion, and he proposed a successful phenomenological model incorporating electron response. He was one of the pioneers to understand the lattice dynamics of d-electron metals (e.g., copper and nickel) using a non-interacting s and d bands model. He investigated the electronic band structure using Korringa-Kohn-Rostoker method. The virtual crystal and the coherent potential approximation were used to calculate the electron states in a number of disordered binary alloys. He was one of the rarest Indian scientists who contributed a Chapter in Solid State Physics, published by Academic Press in 1968 on Lattice Dynamic of Metals, and other contributors in this book included Charles Kittle. For his outstanding work, he was awarded with prestigious Shanti Swarup Bhatnagar Award (Physical Sciences) in 1972 and Meghnad Saha Award for Research in Theoretical Sciences in 1974. His group investigated physical properties like electrical conductivity, Hall Effect and surface segregation in disordered binary alloys. His contributions to electron correlations in narrow band ferromagnets using the Hubbard model and its generalizations are highly appreciated. He was elected as a Fellow of Indian Academy of Sciences, Bangalore, Fellow of Indian National Science Academy (INSA), Indian Academy of Sciences (IAS), National Academy of Sciences India (NASI), Third World Academy of Sciences (TWAS), and Russian Academy of Sciences (Foreign Member).

In 1986, he moved from IIT Roorkee to New Delhi to take over the position of the Director of National Physical Laboratory (NPL). It was a coincidence that the discovery of high temperature superconductors also took place in 1986. His expertise in the lattice vibrations made it easy for him to take the research activities of high temperature superconductors at NPL. He proposed a new variational method for the periodic Anderson Model to study the ground state behavior of heavy fermions and estimated the c-axis resistivity of high temperature superconductors. NPL also started the work on nanotechnology. He investigated transport of electrons in mesoscopic systems, particularly the conductance of a single quantum dot and a double quantum dot system. Apart from being an outstanding scientist, he was a visionary leader as well. For visitors coming to NPL, he got a guest house built at NPL campus so that they can work comfortably even beyond the office hours. To attract research scholars to NPL, he got a hostel built for them. For his distinguished contributions in science, Government of India honored him with Padma Shri in 1991.

In 1991, Prof. S.K. Joshi was elevated to the position of Director General of CSIR and Secretary, DSIR, Government of India. It was the time that coincided with beginning of the economic liberalization in India and he successfully steered CSIR for the national scientific and technological needs.

After his superannuation in 1995, his official address became “252, National Physical Laboratory, Dr KS Krishnan Marg, New Delhi” and remained till his demise. The NPL Research Council, chaired by Prof. Arun K. Grover suggested that he should continue as “Scientist of Eminence” at NPL and his vast knowledge should be utilized by the scientists of NPL. He served the nation in various ways. He played a crucial role in establishing new institutes of higher learning, viz, IISER, NISER, new IITs etc. He guided leading institutions of the country through the Chairmanship of their apex Boards, including IIT Roorkee, Institute of Mathematical Sciences, Chennai, Institute of Physics, Bhubaneswar, Indian Association for Cultivation of Science, Kolkata, Recruitment Assessment Center (RAC DRDO), Recruitment Assessment Board (RAB CSIR), Visvesvaraya National Institute of Technology (VNIT Nagpur), Inter-University Accelerator Centre (IUAC), UGC-DAE, Indore etc. He also served as a member of the Scientific Advisory Committee to Government of India. He was the Chairman of selection committees to select Directors and Vice Chancellors of many prestigious Institutes and Universities. For his contributions, in 2003 he was honored by Padma Bhushan, the third-highest civilian award in the Republic of India.

In 2015, when I took over the position of Director, NPL, I made a courtesy visit to him. It was a coincidence that he also just took over as the Chairman of the National Accreditation Board for Testing and Calibration Laboratories (NABL). We had a great discussion on how NPL (the apex body of measurement in the country) and NABL (the apex accreditation body of laboratories in the country) can ensure the quality of Made-in-India products at par with international standards. It was agreed upon that NPL will increase the Calibration and Measurement Capabilities (CMCs) and the International Bureau of Weights and Measures, France and NABL will try to increase the number of accredited laboratories across the country, which are metrological traceable to SI units of measurements though NPL. In addition, NPL launched several Certified Reference Materials, under the trademark of Bhartiya Nirdeshak Dravyas (BNDs) that provides direct measurement traceability to the laboratories. Many of the BNDs were launched by Prof. Joshi himself. He used to say that NPL should develop all the BNDs so that India becomes self-reliant.

At the end of December 2019, when he started feeling weak the responsibility of the Chairman, NABL was entrusted to me. During my last meeting with him, I ensured him that I will carry forward the good work done by him. I was waiting to end the lockdown to tell him that during the period of COVID pandemic, NABL has done a wonderful job by providing the on-line accreditation to 142 medical testing laboratories across the country for RT-PCR RNA Virus/COVID-19, which has greatly benefited the country in terms of conducting these very important tests. Unfortunately, he left us before I could inform him.

Prof. Joshi immensely contributed to Indian science and academies by serving at various positions including Secretary, Indian National Science Academy (INSA), Foreign Secretary of the Indian National Science Academy (INSA), President of the of the Indian National Science Academy (INSA), Vice President of the Indian Academy of Sciences, President of the National Academy of Sciences President of Indian Physics Association, President of the Materials Research Society of India, President of the Indian Science Congress Association. Prof. Joshi was the brainchild behind enhancing the industry-academia interactions, and bringing the national labs to the ambit of deemed universities e.g., TIFR, HBNI etc. He was also the Chairman of the elite committee that established 5 DST-Centres Higher Education Institutes, including the Panjab University, Chandigarh. He was awarded a D.Sc. honoris causa from Kumaun University, Kanpur University, Benaras Hindu University, and the University of Burdwan.

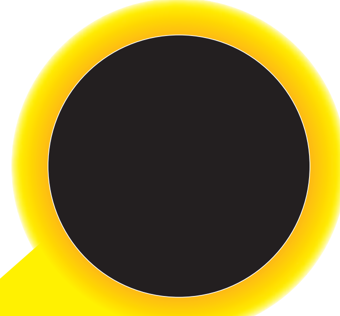
His passing is a great loss to the nation. Those of us who have been fortunate enough to know and work with him have lost a great teacher and mentor.

Prof. S.K. Joshi was married to Hema, a gracious and charming lady, who during their 55 years of togetherness supported him in his personal (a strict follower of early to bed and early to rise) as well as professional (follower of simple living and high thinking) life. He leaves behind his wife and a son Sanjay, who is well settled at a high position in the USA with his family.

Dr Dinesh K Aswal is Director of CSIR-National Physical Laboratory, New Delhi.
Email: dkaswal@nplindia.org

DISCOVERING ECLIPSE

Chavi



An unusual feeling got over me! I felt a sense of commotion,
It was my fourth month; perhaps that filled my mind with such emotion.
Craving for loads of sugar was at an all time high,
And how much I missed my mother...it nearly made me cry.

"You can't leave," Frail voice of my mother-in-law exclaimed from the other room,
"It's the day of solar eclipse, you go outside and our heir is bound to face doom."
The shadow of Rahu Ketu will create some undesirable obstructions,
Leaving the house is considered a bad omen, owing to all the superstitions.

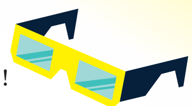
I took it upon me to pop the bubble of myths running in families for generation,
You could mistake it for an act of gallantry, but, I gathered everyone and made a declaration.
"Together we will view the solar eclipse and its mysteries!"
It is all an alluring interaction of the Sun, the Earth, the Moon and their trajectories.

The mighty Sun is the star around which our Earth revolves,
And circling around the Earth is something in which Moon always involves.
When these three celestial bodies come across in the same line,
Shadow of the moon conceals what we see of Sun, and it appears to not shine.

We humans could not decode the science behind this sudden loss of light,
A fire of myths and superstitions hence it did ignite.

But seeing hope in their eyes with logic prevailing over fallacies, made me delighted,
The barrier of delusions drove us apart, nonetheless science united.

"Now let us all experience this magnificent show," said my father-in-law,
After watching the beautiful eclipse through solar glasses, they were in awe!!



The author is Project Associate in Vigyan Prasar.
Email: chavi@vigyanprasar.gov.in

COVID-19 articles

The articles of your May issue came at the right time. The article on the structure of SARS-CoV-2 has been really informative.
The article is written in such an interesting way that it was easy to explain the working of the virus to young children. Once we know why we should not touch our eyes, nose or mouth often, it becomes easy to follow the instruction.
It is rightly said, “Knowledge is power. True knowledge sets you free.” Looking forward to more such useful information on this extremely contagious virus.

Shewta Bhonsle, *Pune*

Vaccine and COVID-19

Dear Dream 2047 Team,
Thanks for bringing out a special issue on COVID-19. Each and every article was very informative. The one on vaccine development was particularly informative as I came to know why development of a vaccine is a long process. Also, the article on fact checks should be widely publicized so that more people become aware of the misinformation on the pandemic. Sharing the trustworthy web resources and also the ones for online courses etc. was also quite helpful.

Kaushik Das, *Bolpur*

The Pandemic Threat

Along with scientific articles, the article on impact of the pandemic on Indian agriculture and economy were also informative. To be self-reliant we all should focus on strengthening our agricultural system, on growing and consuming locally to reduce carbon footprint due to transportation. If you can publish some articles on urban and organic agriculture, hydroponics, permaculture and vermicompost that would be of great help to people like us, staying at cities.

Shatadru Mishra, *Bhubaneswer*

REQUEST TO THE AUTHOR

Science writers, scientists, science communicators, doctors, journalists, teachers and researchers interested in popular science writing are requested to send their articles for publication in Dream 2047 in 1500 to 2000 words in English or Hindi language. Also, send high resolution images relevant to the article that can be published. Your articles can be based on the latest research in the field of science and technology, history of science, health and medicine, agriculture, energy, water, interviews with eminent scientists and working of science laboratories. Suggestions, feedback and letters from authors and readers are welcome. You can contact us by **email:** dream@vigyanprasar.gov.in