International Solar Eclipse Conference

A crossroad on physics and eclipses of the sun

Invited lecture

Dr. Jay Anderson, Environment Canada, Winnipeg, Manitoba

The Meteorology of the Lunar Shadow

Eclipses provide a unique opportunity to study the atmosphere's reaction when incident solar radiation is suddenly turned off and then on again. While the responses are similar to those that occur as night falls, the eclipse is more abrupt than the gradual decrease in solar energy as the evening sun approaches the horizon. The entire eclipse takes approximately three hours with the largest decline in solar energy confined to a 90-minute period; at most eclipse locations the shadow passage is followed by an equally abrupt return to daylight.

Responses to the eclipse can be detected from the sub-surface soil layers to the mesosphere. Most are relatively subtle though even casual observers will notice the decline in temperature and its subsequent recovery. Historically, atmospheric measurements were primarily concerned with surface temperature but recent advances in technology, data density, and numerical modeling have encouraged a much wider range of measurement. Theoretical studies suggest that a "bow wave" is produced in the atmosphere in response to the supersonic passage of the lunar shadow but detection of the wave in barometric measurements has been inconclusive. Radar observations may have finally detected such waves, but at a scale that suggests that much more modeling remains to be done.

This presentation will travel through history from Babylonian to modern times to examine the record of meteorological observations under the lunar shadow.

Invited lecture

Dr. B. Ralph Chou, Associate Professor, University of Waterloo School of Optometry, Canada

Solar eclipse eye safety

Controversy over the safety of materials used in solar eclipse viewers continues to needlessly frighten and confuse the public. The properties of the ideal solar filter are compared with those of filters presently available to solar observers. The analysis of aluminized polyester solar filters with suspected coating defects is presented. Modifications to the technical specification for solar filters made in response to concerns over coating defects in aluminized polyester filters are reviewed.

Invited lecture

Dr. Fred Espenak, NASA Astronomer, Goddard Space Flight Center, USA

Solar Eclipse Predictions for 2001 and beyond...

On 2001 June 21, a total eclipse of the Sun will be visible from within a narrow corridor which traverses the Southern Hemisphere. The path of the Moon's umbral shadow begins in the South Atlantic, crosses southern Africa and Madagascar, and ends at sunset in the Indian Ocean. A partial eclipse will be seen within the much broader path of the Moon's penumbral shadow, which includes eastern South America and the southern two thirds of Africa.

Detailed predictions for this event have recently been published in NASA TP 1999-209484 (Espenak and Anderson, 1999). Topics covered include besselian elements, geographic coordinates of the path of totality, physical ephemeris of the umbra, topocentric limb profile corrections, local circumstances for approximately 350 cities, maps of the eclipse path, weather prospects, the lunar limb profile and the sky during totality.

The NASA eclipse bulletins are prepared in cooperation with the Working Group on Eclipses of the International Astronomical Union and are provided as a public service to both the professional and lay communities, including educators and the media. The bulletins are also available on the Internet via the GSFC Solar Data Analysis Center home page (umbra.nascom.nasa.gov/eclipse/). Additional predictions, maps and data are posted at a special web site for the 2001 eclipse (sunearth.gsfc.nasa.gov/eclipse/TSE2001/TSE2001.html).

A brief overview of eclipses from 2001 through 2010 will also be presented and is available on-line at sunearth.gsfc.nasa.gov/eclipse/SEcat/SEbrief2.html. During the first decade of the Third Millennium, there are twenty eclipses of the Sun with the following statistical distribution: Partial = 4 = 20%, Annular = 8 = 40%, Total = 7 = 35%, Hybrid = 1 = 5%

Global maps show the geographic region of visibility for each eclipse. Some of the more significant events of the next decade will be discussed in greater detail.

Invited lecture

Prof. Eijiro Hiei, Professor of Meisei University, Professor Emeritus of University of Tokyo, Japan

Physical Conditions of Coronal Structure obtained from Eclipse Observations

Collaborative observations of the corona during a total solar eclipse have been recently made from ground-based telescopes and from instruments on board satellites. The data measured in the collaboration are not only of visible region but also of EUV and X-rays, which are valuable in understanding the physical conditions of the solar corona. In the 1994 eclipse in South America, we observed the polar plumes at the north and south polar region from the ground in Paraguay and almost simultaneously from the Soft X-ray Telescope (SXT) on board the Yohkoh satellite. The polar plumes are clearly seen on the photographs taken in Paraguay, but almost unseen on the SXT images, which suggests that the temperature of the polar plumes are not as high as 2 million K, the temperature that corresponds to the SXT observations.

At the time of the 1997 eclipse, the Extreme-ultraviolet Imaging Telescope (EIT) of the Solar and Heliospheric Observatory (SOHO satellite) observed the corona. The polar plumes are clearly seen on EIT images, especially on Fe IX/X images rather than on Fe XV images. Since the temperature typical of Fe XV (14 times-ionized iron) is higher than that of the Fe IX and Fe X (eight and nine times ionized iron), the results suggest that the temperature of the polar plumes is about 1 million K. I shall talk on the analysis of the eclipse data by using the ground-based observations with the satellite observations.

Invited lecture

Dr. Barrie W. Jones, Head of the Physics and Astronomy Department at The Open University, United Kingdom

Shadow bands, and other atmospheric effects of solar eclipses

Shadow bands are an intriguing phenomenon often seen when the Sun has been reduced to a thin crescent. Flickering faint bands of light and shade move across the landscape. The observed characteristics of shadow bands will be described, and will be compared to a theory of the bands. The sort of further measurements that are needed will be outlined.

The temperature drop during a solar eclipse is a familiar phenomenon. Less familiar are the predicted and observed effect on atmospheric pressure, and the prediction of infrasonic waves in the lower atmosphere. Have any such waves really been observed?

Invited lecture

Dr. Serge Koutchmy, Astrophysicist at the Institut d’Astrophysique de Paris-CNRS, France

Coronal dynamics and motions

Both high resolution imaging and spectroscopy can be used at eclipses to analyze dynamical phenomena inside the corona. Different spatio-temporal scales should be considered. We first remind some past results concerning:

1/ The measurements of proper motions using different imaging techniques;

2/ Doppler shifts and line widths measurements to deduce the turbulent and the bulk velocities.

We then consider what are the best diagnostics to be specifically designed at eclipses, in order to efficiently bring some insights into the fundamental problems of coronal heating and of coronal mass loss.

The building up of a coronal region showing high loops and cavities was observed at the last Aug. 11, 1999 total eclipse, well before the onset of a large CME observed later in space, with the SoHO instruments Lasco and EIT.

We consider the white-light eclipse images which permit to point out this slowly evolving CME precursor and we discuss its possible interpretation, noting the absence of a helmet streamer above.

Further, we discuss the preliminary results of a specially designed spectroscopic experiment to look at the radial behavior of coronal waves; the experiment was run during the rather short totality and over a clear sky of a site in Iran (near Chadagan). The variations of the corrected full widths of the coronal green line of Fe XIV at 530.3 nm will be shown all around the corona and a first conclusion will be extracted regarding the importance of waves in the intermediate corona.

Finally, some recommendations will be proposed to improve this diagnostics in the future based on the use of a slit spectrograph and fast detectors.

Invited lecture

Dr. Ed C. Krupp, Director Griffith Observatory, USA

Devoured by Darkness, Eclipse Lore and Myth

To our ancient ancestors, an eclipse challenged the stability and integrity of heaven and so threatened order and life on earth. Because the moon's silhouette made it look as if some unseen celestial powerhouse was taking a bite out of the sun, civilizations as distant from each other as the Vikings, the Chinese, the Maya, and the Hindus all saw eclipses as unsettling combats between a heavenly god and a devouring monster. This program will survey ancient eclipse lore, solar and lunar, from around the world, to spotlight the underlying meaning eclipses once had for us. In time, the ancients learned to predict eclipses, and of course, their success gradually transformed the eclipse experience. People used to do all they could to avoid an eclipse. Now we seek them out. Total eclipses have been domesticated into great recreational events. More people than ever now now follow the eclipse path, and today's cultural responses to eclipses encourage continued eclipse anthropology.

Invited lecture

Mr. Paul D. Maley, Expedition Coordinator for the NASA Johnson Space Center Astronomical Society (Ring of Fire Expeditions), Vice President of the International Occultation Timing Association, USA

Observing an eclipse away from the centerline: a curse or an opportunity for research?

The historical paradygm for most eclipse goers is to monitor the eclipse where you can see the maximum amount of totality. It is heretical to think that you can see more features from an eclipse if you approach the boundary between 100% totality and 99%. Yet this is true. The corona, planets, shadow approach, effects on the environment, diamond rings, chromosphere, prominences are all observed here. There is not a single feature of a total solar eclipse that cannot be observed from just within the limit lines at both the north and south edges. The major feature that is not readily observed by centerline people is the Baily's Beads. The tangential intersection between lunar and solar limbs prolong this effect drastically at the limits. Additional positive aspects of being at the edge include: a) lack of observers competing for valuable ground space, b) psychic challenge of reaching the limit line which often may be in an obscure location, c) ability to see the detailed formation and dissipation of individual Baily's Beads both before 2nd contact, during totality,and after 3rd contact, d) potential contribution to solar diameter research efforts, e) less traffic problems going and coming from the site, f) a completely different perspective of viewing the eclipse (and reaching the site) compared to centerline goers, g) no hords of local onlookers. There are penalties to be sure: a) vastly reduced totality time, b) requirement for a precision navigating aid to be sure you do not overshoot or undershoot the site, c) less flexibility in locating the proper site, d) incredulous looks from your centerline-going colleagues.

Yet an ongoing program by the International Occultation Timing Association attempts to collect data that is to be used in advancing the understanding of changes in the solar radius between eclipses. Informally, this effort began as long ago as 1973. The NASA JSC Astronomical Society views this as a public outreach program is available to anyone with an interest in contributing to the science. Instrumentation required in 2001 include commonly available telescopes like the Celestron 5, inexpensive black and white TV cameras such as Supercircuits PC-23C and Sony camcorders. This program does not require a level of prior experience, nor does it reject participants because they do not have appropriate scientific background. We describe the methods used to observe at the edge, benefits of pre-eclipse simulations, accounts of prior eclipses observed, and the byproducts of those eclipses. A compounding factor is a large amount of data accumulated to date, by varied equipment, and the rather difficult problem in reducing this data. Much of the information lies on the shelf awaiting funding and improvements in workstation data processing, while additional data from successive eclipses continues to be added to the backlog. Early papers have been published, but conclusive results have not yet been forthcoming. Future plans are described for achieving data reduction and similar applications for lunar eclipses.

Invited lecture

Prof. Jay M. Pasachoff, Field Memorial Professor of Astronomy at Williams College, Williamstown, Massachusetts, USA; Chair, Working Group on Eclipses of the International Astronomical Union:

Solar Eclipses: Teaching Us About the Sun

Total eclipses are a unique opportunity for those of us on Earth to observe the solar corona. In recent years, new instruments and new theoretical ideas have given us a different set of scientific projects to investigate than the eclipse projects of years past. Further, the liaison of eclipse observations with near-simultaneous observations from satellites taken from outside the eclipse path on eclipse day allow improved calibrations of the routine satellite observations as well as deeper understanding of the structure of the outer layers of the Sun as they are displayed by all the instruments together. How do temperature and polarization vary in the solar corona? Why is the coronal gas millions of degrees hot? Can we trace back coronal structure to its footpoints on the solar surface? All these and others can be explored during eclipses for a fraction the cost of space observations. I describe how some of the 29 solar eclipses I have seen bring us closer to our goal of understanding the sun.

Invited lecture

F. Richard Stephenson, University of Durham, England.

Historical eclipses and changes in the Earth's spin rate

Ancient and medieval observations of solar and lunar eclipses yield surprisingly accurate information on long-term trends in the Earth's rate of rotation. Analysis of these data demonstrates that although tides are mainly responsible for long-term changes in the length of the day, other mechanisms have significant effects.

Early eclipse records mainly originate from four major cultures: ancient Babylon, ancient and medieval China, ancient and medieval Europe, and the medieval Arab world. The very earliest reliable records date from around 700 BC. Because approximately one million days - each a fraction of a second shorter than at present – have elapsed since this early epoch, the cumulative clock error arising from changes in the Earth's rate of spin can amount to several hours. This is readily measurable using even primitive observations.

The bulk of the useful observations are in the form of timings of both solar and lunar eclipses. However, as has long been recognised, untimed total solar eclipses have an important role to play. In addition, observations in which the Sun or Moon rose or set whilst eclipsed occasionally prove of value. Analysis of these various data sets indicates that in opposition to the tidal rate of increase in the length of day of 2.3 milliseconds per century (ms/cy) there is a non-tidal decrease at a mean rate of 0.5 m/cy. This increase is variable on the millennial time-scale and may be due to such diverse effects as post-glacial uplift, core-mantle coupling and changes in global sea-level.