

SOLAR PHYSICS IN INDIA

V. Krishan and J. C. Bhattacharyya

Indian Institute of Astrophysics

The first solar observations were taken at Kodaikanal in 1901. There were instruments to visually examine the prominences around the solar limb and the spectra of sunspots. Photographic studies included daily white-light photography of the solar disk and monochromatic chromospheric pictures with the spectroheliographs in the light of the lines of ionized calcium and of hydrogen. The uninterrupted series of photographs continues until the present day and forms one of the most unique collection of a record of solar activity available anywhere in the world. The observatory has acquired several new instruments: (1) The new instrumentation at the solar tower consists of a large solar telescope combined with a powerful spectrograph of exceptionally high dispersion and resolving power; the solar telescope consists of a coelostat with three telescope object glasses of 37.5 cm and 20 cm aperture; (ii) a coronagraph of 20 cm aperture; (iii) a monochromatic heliograph with Lyot filter.

The large solar telescope has now a photoelectric magnetograph which makes fine measurements of magnetic and velocity fields on the Sun possible. The tower telescope has been used for high resolution studies of the solar chromosphere, of the Evershed effect in sunspots and the five-minute oscillations observed on the solar surface. It has also been used for the study of evolution of active regions and some of the characteristics of chromosphere over such areas. A very significant contribution with its aid has been the identification that bright fine mottling in the chromosphere is responsible for the relationship found by Wilson and Bappu between K emission line widths and absolute magnitudes of stars.

Solar Eclipse Studies

During the period 1950–1983 the Indian Institute of Astrophysics participated in the observations of six solar eclipses. An expedition headed by A. K. Das went to Iraq in 1952 and to Ceylon in 1955. M.K.V. Bappu led the next three expeditions to Maine, USA in 1963, Miahautlan, Mexico in 1970, and India in 1980. In 1983 a five-member team led by K. R. Sivaraman went to Tanjung Kodak in Indonesia.

Solar corona research formed the main aspect of these eclipses. Among the important observations during the expedition, the high resolution coronal photographs with 6 m focus horizontal camera and a fine coronal spectrogram deserve special mention. During the 1970 eclipse, Bappu, Bhattacharyya, and Sivaraman identified on the coronal spectrogram emission lines of Balmer series, the helium D_3 line, and H and K lines of ionized calcium which indicated the presence of relatively cooler regions in the corona. These findings were confirmed from the results obtained by the 1983 eclipse team.

During the eclipse of February 1980, the high dispersion multi-slit coronal spectrograph, the spectrograph for rapid sequence photography of the neutral potassium line close to the solar limb, a Paschen Range monochromator for limb darkening measurements and a telescope with the 0.5Å H-alpha filter were used. The equipment consisted of moelera photoelectric image intensifiers, narrow-band polarizing filters. White-light photographs of excellent quality showed the presence of coronal transients. The multi-slit spectra helped in mapping the turbulent velocities in the corona.

Japal-Rangapur Observatory

During the 1980 eclipse, special observations of gravitational deflection of light were concluded at Japal-Rangapur Observatory. In addition, polarization studies of solar corona in red and blue light for determining the electron densities were made using the 4½-inch telescope with polaroids mounted on the 48" telescope.

Uttar Pradesh State Observatory

Observational and theoretical studies of dissociation equilibrium and profiles of diatomic and triatomic molecular lines based on the various sunspot, photospheric and average facular models are in progress. Studies of magnetohydrostatic and magnetohydrodynamic models of prominences have been undertaken. The observatory participated in the observation of solar eclipse 1980 and carried out a program on coronal photometry and photography of the flash and coronal spectra.

Udaipur Solar Observatory

For optical studies of the Sun, a special solar observatory as been set up in Udaipur, Rajasthan. It has a 12-ft solar telescope for high spatial and time resolution studies of chromospheric and photospheric flares and other transient phenomena. The telescope is located in a small island in the midst of Fateh Sagar Lake. Owing to the presence of a large body of water, seeing conditions are excellent over long periods during the day.

Solar Radio Astronomy

At the Kodaikanal Observatory, radio astronomy had its beginning in the year 1952 under A. K. Das when continuous recording of solar radio noise flux was commenced using a 100 MHz interferometer with twin yagi-type antennas. This telescope was designed and built locally, using the observatory's own facilities. With available instruments, scintillation observations of cygnus A and Cassiopeia A were made. In the 1962 a Kodaikanal-Yale project of recordings of the radio radiation of Jupiter at a frequency of 22.2 MHz was also started. Later a 3000 MHz radiometer was in regular operation for solar patrol on a tracking 2-meter diameter paraboloid.

In the 70's a collaborative project between Indian Institute of Astrophysics and Raman Research Institute, Bangalore was commenced. A Decameter Wave Radio Telescope was jointly set up by the two Institutes at Guaribidanur, 100km

north of Bangalore, which became operational in 1979. At present it is one of the largest telescopes of this type in the world. It consists of two long-antenna arrays, one oriented in E-W and the other in N-S direction, of lengths 1.5 km and 0.8 km, respectively. Operating at a wavelength of 10 meters, the telescope can resolve objects whose angular separation is about 25 minutes-of-arc in the sky. Some of the important studies made using the Decameter Wave Radio Telescope include the detection of continuum radiation from the outer solar corona during quiet periods, and studies of solar absorption and emission bursts.

Physical Research Laboratory

PRL had started with solar radio observations in late sixties and installed a radio spectrograph for studies of solar bursts. Their interest, however, later changed to interplanetary scintillations (IPS). At the present moment they are setting up a three-station array operating at 103 MHz for these studies. The three stations are located at Thaltej (near Ahmedabad), Rajkot, and Surat.

Osmania University

For observations during the total solar eclipse of February 16, 1980, the center entered into a collaborative plan with PRL and S.A.C. Ahmedabad for observing the Sun in cm wavelengths. Such a setup with a 10-ft steerable dish was installed at Japal-Rangapur Observatory in early 1980 by means of which high resolution microwave brightness temperature measurements were made during the eclipse. The equipment has been retained at site where regular observation of solar flux at 10 MHz are now being carried out.

Cosmic Ray Research

At PRL ground-based cosmic ray detectors were used to study temporal variations in their intensities. For these, results of great importance were obtained in fields such as periodic intensity variation, modulation of cosmic rays in the heliosphere, properties of the interplanetary medium, solar flare effects and solar wind effects. Nuclear Research Laboratory at Gulmar, Aligarh Muslim University and APS University at Rewa are engaged in solar modulation studies. Research in theoretical solar physics is extensively being carried out by groups in I.I.A., T.I.F.R., U.P.S.O. and in several universities on almost all aspects of the Sun and its environment. In particular, the studies of helioseismology convection zone, dynamo, photospheric modeling, coronal structures, heating, MHD processes, radio and X-ray emission processes, to name a few. In Nainital, theoretical studies concerning the formation of molecular lines in the Sun is actively being pursued.