☆ STAR DUST

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 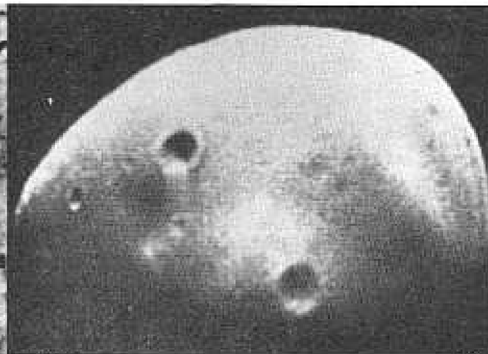

Phobos Deimos NASA

MORRISON: EXPLORING SMALL WORLDS

Dr. David Morrison, NASA Headquarters, will address the October 1 NCA meeting on NASA's plans for probing asteroids and satellites of the planets.

Because of their large size, the planets are complex and highly evolved; smaller bodies offer simpler clues to the origin of the solar system. Thus, NASA's attention is increasingly directed to the asteroids, which may be the fragmented remnant of the original planetesimals out of which the planets formed. The satellites, also, are revealed as individual worlds, varying from mere pieces of rock to Titan, which is larger than Mercury and has an atmosphere comparable to that of the Earth. What is known of these objects will be reviewed, and some of NASA's plans for their exploration by spacecraft will be discussed.

Dr. Morrison is Assistant Deputy Director, Lunar and Planetary Studies, NASA. He holds a degree in physics from the University of Illinois and a Ph. D. In astronomy from Harvard. He was formerly associated with the Institute for Astronomy, University of Hawaii, and spent a sabbatical year at both the Lunar and Planetary Laboratory of the University of Arizona at Tucson, and the Kitt Peak Observatory.

OCTOBER CALENDAR — *The public is welcome.*

Saturday, October 1, 6:15 PM — Dinner with the speaker at Bassin's Restaurant, 14th Street and Pennsylvania Avenue, NW. Reservations unnecessary.

Saturday, October 1, 8:15 PM — NCA monthly meeting at the Department of Commerce Auditorium, 14th and E Streets, NW. Dr. Morrison will speak.

Monday, October 3, 10, 17, 24, 31, 7:30 PM — Telescope-making classes at Chevy Chase Community Center, Connecticut Avenue and McKinley Street, NW. Information: Jerry Schnall, 362-8872.

Friday, October 7, 14, 21, 28, 7:30 PM — Telescope-making classes at American University, McKinley Hall basement. Information: Jerry Schnall.

Saturday, October 8, 7:30 PM — *Exploring the Sky*, presented jointly by NCA and the National Park Service. Glover Road south of Military Road, NW, near the Nature Center. Information: Bob McCracken, 362-8872.

Saturday, October 15, 4:00 PM — NCA picnic hosted by Byrds. Details on page 7.

SEPTEMBER LECTURE

Dr. George A. Doschek of the U.S. Naval Research Laboratory opened the 1977-78 NCA lecture series on September 10 with an update on Skylab solar results from XUV observations in the range 200-2,000 Å.

Dr. Doschek described new spectrographic techniques, the data, and newly developed reduction methods that have made possible measurements of temperatures, densities, volumes, energies, and motions previously unknown. He discussed the large flare of June 15, 1973 in particular.

Above the 6,000 K solar photosphere, the 30,000 K chromosphere extends upward to about 2,000 km. There, in the transition zone, the temperature rises sharply to about 1.5×10^6 K in the corona. Measurements within the transition zone are necessary to a study of the enigmatical energy balance between the corona and the chromosphere.

Some possible mechanisms are known whereby the corona might be heated by wave energy from the chromosphere through the transition zone, but the process is not known.

Near active regions the strong local magnetic fields constrain the plasma to magnetic loops; coronal temperature and density are quite heterogeneous. A He II spectroheliograph (304 Å, 80,000 K) shows supergranular cells whose mechanical energy is being transported, probably by a wave process, through the transition zone to the corona. The granules are similar to those previously seen in white or H II light on the photosphere.

Flares have now been observed over a wide spectrum from Skylab, including He, Si, and X-rays, and have been found to occur in magnetic loops. This was one of the major finds of Skylab. Previous H II observations (through the atmosphere) yielded little understanding of flares, because apparently the primary energy release of flares is in the corona, not the chromosphere, where the 80,000 K H II observed emission represents a secondary manifestation.

The trapped-plasma temperature reaches its highest — about 3×10^7 K — at the tops of the loops. This is a new Skylab finding not yet quantitatively understood. Heat is both radiated away and conducted down the plasma tubes (along the magnetic lines) to the chromosphere, where excess energy explodes matter away at the magnetic feet of the loop.

Most of the Skylab spectra Dr. Doschek discussed were made with a normal-incidence slit spectrograph. Some of the lines shown from 1,150 to 1,950 Å are C III, H II, N V, Fe XII, O I, C II, Si IV, O IV, C IV, which are also the strongest lines in the UV spectra of quasars. These lines occur at individual temperatures from about 8,000 K for O I to about 1.5×10^6 K for Fe XII, so wherever they occur, temperatures can be read over a wide range. Another line, which occurs during flares, is Fe XXI, a broad line at 10^7 K. Of course, these lines are not observable through the atmosphere.

When one of these ions captures a free electron, it is excited to a higher energy state for perhaps 10^{-10} sec or so, when it decays back to the ground state with the emission of a quantum at the wavelength characteristic of that particular transition. The resulting observed spectral line is doppler broadened by the thermal velocity distribution of the involved electrons. Plasma turbulence velocities also broaden the line. Ion temperatures may differ from the electron temperatures. In a flare, however, the turbulence velocity broadening is so far greater than the ion temperature broadening that the latter can be neglected, so the full-width-half-maximum (FWHM) of the line is a measure of turbulence.

If the plasma is in thermal equilibrium, the electron velocity distribution is Maxwellian, and the observed line shape is Gaussian; conversely, if the observed line is Gaussian, thermal equilibrium is indicated. Displacement of the center wavelength indicates the radial velocity of the plasma mass. The intensity of the line is proportional to the energy, ion density, plasma volume, and C, an atomic parameter. C times density is the rate at which electrons excite the upper level. Ion density is proportional to electron density. Thus, the intensity of the line is proportional to the square of the electron density times the volume. This quantity, D^2V, is given by many types of lines. If D can be determined, then V can be, and, in turn, the thermal energy of the gas can be found — not easy until recently.

The NRL group has developed a technique for determining D by measuring the intensity ratios between certain pairs of lines from three-level ions.

In these ions, the short-lived permitted states decay radiatively, producing one line. If ions are simultaneously excited to another, metastable, state, a much longer time, perhaps microseconds, will elapse before spontaneous radiative emission occurs to produce the second line of the pair. During that interval, the ion is exposed to a probability of collision-induced non-radiative deexcitation which is a function of density. Thus, at low density, both lines are observed; at high density, the density-sensitive line is weaker, the upper state having been partially depopulated by collisions.

The ability thus to measure densities in the transition zone and corona is one of the major accomplishments of the Skylab program, Dr. Doschek said.

On June 15, 1973, the largest solar flare observed by Skylab occurred. Our speaker described the recent application of the foregoing techniques to the reduction of the XUV data, and the resulting new knowledge of the structure of solar flares.

Skylab spectroheliograms in He II (80,000 K) and H II (10,000 K) are similar. In the 255 Å line of Fe XXIV (2×10^7 K), however, several flux loops were seen, some having temperatures of 3×10^7 K at their tops, decreasing through the transition zone into the chromosphere. During the cooling phase, features seen in Fe XXI (10^7 K) declined, while those in Fe XII (1.5×10^6 K) intensified. The lower temperature lines, C IV, Si IV, N V, Si III, Si II, O I, all below about 10^5 K, did not share the pattern of the high temperature lines, but behaved impulsively, indicating a surge, or eruption, at the magnetic feet of the flux loops, apparently a result of excessive energy transfer down the loops into the chromosphere. During the surge, radial velocities of erupting plasma varied with temperature from 60 to 84 km per sec; subsequent velocities were all the same. Divergence broadening of about 60 km per sec was seen.

The line-ratio technique shows densities in the surge greater than 2×10^{13} electrons cm^{-3} — as high as in tokomak plasmas generated in the laboratory. the corresponding volumes are small, typically extending about 50 km, or less than 0.1 arcsec on the Sun — beyond optical resolution for solar instruments. Energy considerations show the surge to be a series of such plasma pulses.

Density in the transition zone declined from 10^{12} to 10^{11} during the cooling phase.

Density-sensitive lines are also available at the high coronal temperatures, with which the line-ratio technique, conceived by Feldman, can be used. Fe IX yields quiet-Sun coronal densities of 10^9-10^{10} cm^{-3}, and in flares, 7×10^{10} to 10^{12}. Flare plasma in the corona shows little motion, being magnetically constrained.

Thus, from Skylab much has been learned of the temperatures, densities, motions, energy distribution, and structure of solar flares. A wealth of data remain to be reduced; time will bring new knowledge. But the *cause* of flares is at present not known.

These new data, largely unpublished, will soon appear in the *Astrophysical Journal* in further detail. rm

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BYRDS TO HOST NCA PICNIC

Dick and Nancy Byrd will host NCA at their lake and cabin on Saturday, October 15, from 4:00 PM. Bring food for cooking (Dick has grills) and telescopes, etc. To reach Byrdland:

From Virginia, I-95 south 34 mi from Beltway to U.S. 17; south on 17, cross U.S. 1 at light onto 664; right at light onto 218; left at light onto U.S. 3; about 19 mi farther, just after King George, left onto 205; cross U.S. 301 at light. *Continue 4.4 mi, then right onto 620 immediately after Ninde Post Office. At 0.85 mi turn left onto unmarked private dirt road. Proceed about 700 feet to fork, bear right between chainposts. About 1200 feet farther is a gravel parking area on left. A drivable grass road leads from here to cabin.

From Southern Maryland: U.S. 301 about 10 mi south of Potomac River Bridge, turn left onto 205 and continue as from * above.

NCA thanks Dick and Nancy for their gracious hospitality.

EXCERPTS FROM THE IAU CIRCULARS

1. August 19 — N.S. Chernykh, Crimean Astrophysical Observatory, discovered a 14th-magnitude comet (1977 l) in Pices. Candy, Perth Observatory, finds the period to be 13.01 years.

2. August 24 — J. Grindlay, Center for Astrophysics, obtained a 60-minute exposure with the 400-cm Cerro Tololo reflector showing a new object of red magnitude 21 at the position of the nova-like X-ray source detected in Norma in July.

3. August 31 — S.C. Morris, Dominion Astrophysical Observatory, obtained spectra indicating that CH Cygni was undergoing another outburst. Bortle, AAVSO, noted that its magnitude rose from 7.7 in April to 6.8 in June.

4. September 4 — Merlin Kohler, Quincy, California, discovered a 10th-magnitude comet (1977m) in Serpens Caput with a 20-cm reflector. The orbit determined by Marsden is parabolic, with perihelion on November 10. The comet is moving southeastward, and was last reported to be of 9th magnitude. The predicted position for October 4 is 16h33m +18°02'.

WANTED

Telescope, best offered for $150.00. Former Washingtonian. Contact through *Star Dust*, 5120 Newport Avenue, Washington, DC 20016.

* STAR DUST WASHINGTON, D.C. Published eleven times yearly for NATIONAL CAPITAL ASTRONOMERS, INCORPORATED, a non-profit, public-service organization promoting interest and education in astronomy and related sciences. President, James H. Trexler. *Star Dust*: Robert H. McCracken, 5120 Newport Avenue, Washington, DC 20016. Deadline: 15th of preceding month.

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