- Relocate 25 KVA motor-generator from 2nd floor to basement and install 15 KVA UPS for computers protection
- Remove Coudé turret mirror (M3) handling arm from the telescope
- Assist Hawaiian Public Television crew filming primary mirror aluminizing process.

Most objectives were met. In particular, primary mirror coating was uniform at 870 Å thickness; the primary mirror support system was improved; removal of the M3 handling arm and associated counterweights has reduced telescope moving weight by 3200 kgs; the new main control room layout looks promising.

There were, however, some delays in the course of the work, when as-built and as-installed equipment were found to be different from available design information. In particular, installation of the load cells were aborted when, during lowering of the primary mirror back into its cell, it was discovered that the axial defining pad mechanisms had been modified from the original design, and that the full weight of 14 tons, when the mirror is off-air, is taken by the 3 axial defining pads, located at the outer edge of the mirror. Existing drawings and design information showed that the mirror, when off-air was intended to be supported at 24 locations, uniformly spread over the bottom of the mirror.

The resulting point load concentrations are under investigation, to determine if such conditions are acceptable, and to properly size the load cell weight range. Further engineering work is planned for 1989 to correct other remaining deficiencies (e.g. primary mirror radial support mechanisms, axial and radial defining pads, air pressure support system).

Jerry Sovka

SCIENTIFIC NEWS

Detection of Auroral Emissions on Jupiter at 2.2 μm with the FTS

The UV and the IR aurorae

In early January 1979, the Voyager 1 spacecraft began observations of the Jupiter system in the little explored region 500 to 1700 Å, in a closer view than ever before. The observations revealed an unexpected enhancement of atomic and molecular hydrogen emission, in Lyα and the Werner bands, in the polar regions of Jupiter (Broadfoot et al., 1979). The strong H_2 emission, only present near the poles, was interpreted as a signature of auroral emission, excited by high-energy particle precipitation along the Jovian magnetic field lines, comparable to the phenomenon observed on Earth. The UV Spectrometer on board Voyager 2 confirmed the previous detection. Subsequent observations were carried out with IUE (Skinner et al., 1984), supporting the Voyager's finding, but with poor spatial resolution (10x20 arcsec), and from the ground in the infrared, at 7.8 μm (Caldwell et al., 1980, 1983, 1988). This latter wavelength corresponds to the very intense υ_4 band of methane, which provides information about the Jovian stratosphere. In this experiment, the disk of Jupiter is mapped with a 2 arcsec aperture in a two-dimensional raster pattern. The scans revealed a brightening near both poles which were first thought to be related to auroral (i.e. nonthermal) effects.

However, with further study, significant differences appeared between the two detections. The UV emission is concentrated in zones around each magnetic pole: a) an oval known as the 'Io footprint', the locus near the surface of Jupiter where magnetic field lines through the orbit of Io intersect the atmosphere; b) an auroral arc characteristic of magnetic field lines exiting from the interior of the planet. In the infrared, the emission in both hemispheres is confined to a small spot, of about 3x6 arcsec. The northern spot is fixed, at latitude + 60°, while the southern spot moves in longitude. The position of the northern spot is found to coincide nearly with a magnetic anomaly (at 180° longitude in System III). From analysis of the infrared spectra of Voyager 1, Kim et al. (1985) reported the same localized emission in various hydrocarbon trace gases. High-resolution detection of few line profiles of hydrocarbons from ground-based observations, in C_2H_2 at 13.3 μm (Drossart et al., 1986) and in C_2H_6 at 11.6 μm (Kostiuk et al., 1987), confirmed the previous results. The most intense region, located in the northern hemisphere, is hereafter known as the *Auroral Hot Spot*.

To explain these striking differences, the following idea has been proposed: the aurorae in the two spectral regions, UV and thermal IR, have different source particles. A possible interpretation is a direct excitation of H_2 by the charged particles to produce the UV emission, while the infrared polar brightenings would result from an indirect excitation of the stratosphere (by secondary electrons, ions, etc.) with an intense thermal heating, resulting in a change in the photochemistry. Therefore, only the UV brightenings could be properly described as auroral signatures.

CFHT Observations: new emission lines

The auroral phenomenon and related effects has many implications for understanding the Giant Planet, for the structure of the Jovian magnetic field, the energy of the particles, the chain of reactions resulting from the precipitation of particles, the structure of the atmosphere in the polar regions and the circulation in the stratosphere. To help answering these difficult questions, the exploration of another accessible spectral window is crucial.

H_2 has vibrational transitions (quadrupole lines) in the 2.2 μm region, which have been theoretically predicted to be observable. Since the same molecule is involved in the UV emission and the 2-μm emission, the latter can give the opportunity of recovering all the information intrinsic to the ultraviolet. In addition, the solar reflected spectrum is weak (K mag = 7.4 in 5 arcsec) due to the continuous absorption of the pressure-induced dipole spectrum of hydrogen. So, if the lines are present they can have a high contrast. A tentative identification of the S_1 (1) line has been reported by Trafton et al. (1988) using a 32-element cold grating spectrograph at a resolution of 570 at the best.

For the second semester of 1988, a joint proposal was submitted to the Canadian and to the French allocation Committee, with a J. Caldwell (York University) and P. Drossart (Paris-Meudon Observatory) as co-P.I.'s to observe auroral spots in the K band with the FTS on the CFHT. Also part of the proposal was S. Kim (Goddard Space Flight Center), S. Atreya and J. Clarke (University of Michigan) and J.P. Maillard (IAP). Much higher resolution and the coverage of the entire band were the expected advantages. Five half-nights were allocated, from September 21 to 26, with the French and the Canadian agencies contributing respectively for two and three halves.

The FTS observations were conducted at a resolution of 20,000, with an aperture size of 5 arcsec on the planet. The southern auroral zone was successfully detected for the first time at this resolution and this spectral range. The position of the southern hot spot being unpredictable, the rotation of the planet was used to scan the disk at a fixed altitude. Ten-minute individual spectra were recorded on each location. The 1-0 S_1 (1) line of H_2 was effectively detected at every position, with a variable intensity reaching a smooth peak at a given longitude. A very localized spot would have given a sharper peak. Complete mapping in the 7.8 μm methane band was obtained in parallel at the IRTF by J. Caldwell, as were IUE observations in the UV. In the reduction of these coordinated observations we can compare the location of the emission seen at very different wavelengths.

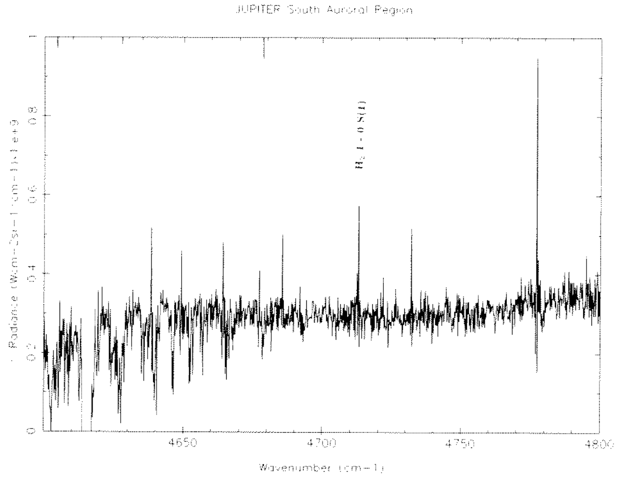

Figure 10: Calibrated portion of the Jupiter spectrum in the southern auroral zone obtained in September, 1988, with the FTS. It shows one H_2 quadrupole line at 2.122 μm (4712.905 cm^{-1}) plus several of the unidentified emission lines detected for the first time. The secondary minima of the apparatus function are visible on the strongest line. The full spectrum covers the entire K band (4100-5100 cm^{-1}). The absorptions below 4680 cm^{-1} are due to CH_4 in Jupiter's atmosphere. The auroral spectrum also shows a broad continuum which may be due to a polar haze.

On the FTS spectra, the most surprising thing was not the detection of the expected quadrupole H_2 line (two more are also detectable), but the discovery of many unidentified emission lines, several being more intense than the S_1 line of H_2 (Figure 10). With the kind help of the Spectroscopy Section at the Herzberg Institute of Astrophysics in Ottawa, which has a unique expertise in molecular hydrogen spectroscopy, we immediately began to identify the mysterious lines. Out of the 28 lines clearly detectable in the Jupiter spectrum and not attributed to quadrupole lines of H_2, 21 were found to have counterparts in a discharge emission spectrum of H_2 at 50 Torr, obtained by W. Majewski, containing H_2 Rydberg lines, H_3, H_3^+ and maybe something else.

So far, the best candidate for most of the lines is H_3^+ in the $2\upsilon_2$ band, according to J. Watson. If confirmed, it would be the first detection in space of this molecule. These new observations have particular importance. They may be the first detection of real infrared aurora (i.e. nonthermal emission). The production of H_3^+ could be an essential link in the formation, deeper in the stratosphere, of more hydrocarbons.

More modeling and more spectroscopic work are required, as are more observations with the FTS, particularly to secure similar observations in the northern zone. The sensitivity, the high resolution and the large spectral range provided by the instrument are essential for a breakthrough in the study of the complex mechanisms of aurorae on Jupiter.

J. P. Maillard and P. Drossart

References

Broadfoot, A.L., et al., Science, 204, 979 (1979).

Caldwell, J., Tokunaga, A.T., and Gillett, F.C., Icarus, 44, 667 (1980).

Caldwell, J., Tokunaga, A.T., and Orton, G.S., Icarus, 53, 133 (1983).

Caldwell, J., Halthore, R., Orton, G.S., and Bergstralh, J., Icarus, 74, 331 (1988).

Drossart, P., Bézard, B., Atreya, S., Lacy, J., Serabyn, E., Tokunaga, A.T., and Encrenaz, T., Icarus, 66, 610 (1986).

Kim, S.J., Caldwell, J., Rivolo, A.R., Wagener, R., and Orton, G.S., Icarus, 64, 233 (1985).

Kostiuk, T., Espenak, F.,Mumma, M.J., and Deming, D., Icarus, 72, 394, (1987).

Skinner, T.E., Durrance, S.T., Feldman, P.D., and Moos, H.W., Ap. J., 278, 441 (1984).

Trafton, L., Carr, J., Lester, D., and Harvey, P., Icarus, 74, 340 (1988).

Inhomogénéités dans les vents d'étoiles Wolf-Rayet

Le phénomène de vent stellaire, commun à la plupart des étoiles et particulièrement important dans le cas des étoiles lumineuses, atteint son paroxysme chez les étoiles Wolf-Rayet (W-R). Cependant, une description quantitative et non équivoque de la nature et de l'origine de ces mêmes vents reste à formuler.

La plupart des experts s'accordent à dire que les étoiles W-R sont les descendants hautement évolués d'étoiles initialement très massives (masse initiale $\geq 40 M_\odot$), de type O. Leurs raies d'émission larges et intenses, même dans le visible, indiquent une perte de masse élevée et rapide ($\geq 10^{-5}$ $M_\odot$ an^{-1}, avec des vitesses terminales υ_∞ ~1000-4000 kms^{-1}).