Preprints, No. 130 and 132, 1980/1981). In the middle infrared the situation was less satisfying, as only a few stars are bright enough to be used as standard stars and the intrinsic energy distribution of these stars is uncertain longward of 5 μm.

The Circumstellar Shells and Mass Loss

Our measurements reveal that the infrared energy distribution of OH/IR stars is quite different from those of known late-type stars having OH emission (Fig. 2). Most of the energy is radiated between 3 and 20 μm with a steep decrease of the spectrum shortward of 3 μm. An absorption feature ascribed to silicate material in the circumstellar shell is present at 9.7 μm. Thus OH/IR stars appear to have thicker shells than those associated with the optically visible Mira variables and M supergiants. Dust shell temperatures range from ~ 400°K for thick shells to ~ 1 000°K for the thinner shells.

The split of the OH emission into two velocity components can be explained by the location of the observed OH masers on the front and back sides of a symmetrically expanding shell. Thus direct evidence for the outflow of material from the star is present. Estimates of mass loss rates are of the order of 10^{-5} $M_{\odot}$/yr or more. This is one hundred times higher than the mass loss rates derived for Mira variables. In a steady state picture OH/IR stars are loosing in about 10^5 years one solar mass, implying that the duration of the OH/IR phase when high mass loss rates occur must be short.

The Central Stars of OH/IR Sources

We have determined periods for the central stars betwen 500 and 1 700 days (Fig. 3) (cf. Proceed. Workshop Phys. Proc. in Red Giants, 1981, in press). These periods are the longest yet found in the galaxy for long period variable stars. The OH/IR stars we have monitored have been shown to be regular variable stars, with amplitudes up to two magnitudes at 2.2 μm.

To get an idea of the evolutionary phase of the OH/IR sources, the nature of the central stars must be determined. It is still a question whether they are M supergiants or M giants (Mira variables) or whether both types are present among them. The large amplitude variations are in contrast to the behaviour of the galactic M supergiants showing OH maser emission; which generally display small amplitude variations and are semiregular. On the other hand the periods have only little overlap with the usual Miras and extend a factor of at least 2 or 3 beyond the longest periods known for Mira stars.

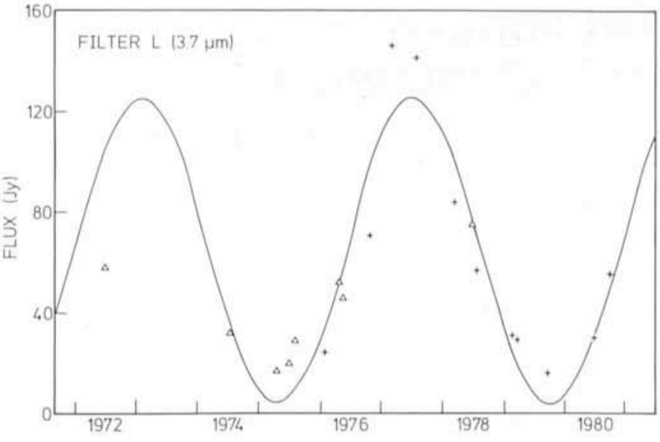

Fig. 3: *Variation of the infrared emission at 3.7 μm of OH/IR 26.5 + 0.6. The period is 1630 days. Crosses are measured at ESO and triangles are taken from the literature.*

We suggest that OH/IR stars are a rarer, more massive class of Mira variables, which, when they evolve upwards the asymptotic giant branch, begin to pulsate with longer periods and at higher luminosities than the optically visible Mira stars. Indeed we have found that the luminosities do increase with period in a way similar to that for Mira variables. This long period pulsation is connected with increased mass loss leading to the formation of the thick circumstellar shells responsible for the strong infrared and OH maser emission.

What is the fate of these OH/IR stars? With such a high mass loss rate the stars must soon lose their evelopes exposing their hot cores. These cores could then ionize the circumstellar material. Maybe OH/IR stars evolve to planetary nebulae.

Acknowledgement

I wish to thank Prof. H. Schmidt, Bonn, for continuous support of the monitoring project.

Observation of Titan at La Silla during a Total Eclipse

M. Combes, T. Encrenaz, N. Epchtein, J. Lecacheux, Observatoire de Paris-Meudon
T. Owen, State University of New York at Stony Brook

The edge-on presentation of Saturn's rings and satellites system has provided a rare opportunity to observe total eclipses of Titan in the shadow of Saturn. This event, which comes back every 16 years, occurred during the first semester of 1980, and eclipses of several hours were observable every 16 days from November 1979 to July 1980.

Information upon thermal properties of Titan's atmosphere may be expected to be obtained from the observation of Titan during and immediately after its emersion from the Saturnian shadow. It should be pointed out that, in spite of the remarkable results obtained on Titan by Voyager 1, its atmospheric structure is still poorly understood, especially concerning the aerosols.

Titan's emersions were marginally observable from Europe at large zenith distances; more favourable observing conditions occurred in Chile, but emersions occurred close to the time of local sunset.

Observations

We decided to monitor the temperatures of the upper atmosphere and the lower atmosphere (as close as possible to the surface temperature) during and following Titan's emersion. We used a short integration time in order to be able to describe properly a time-evolving situation. The temperature of the upper atmosphere was monitored at 12μ in the C_2H_6 emission band; the surface temperature was monitored at 20μ where most of the outgoing flux comes from the surface. In order to look for a phase change of CH_4, we monitored the Titan spectrum, in the CH_4 bands at 0.6–0.9μ, during and after the emersion.

Observations were performed at La Silla on June 28, 1980, both on the 3.6 m and the 1.52 m telescopes. Monitoring of T_B (12μ) and T_B (20μ)was performed at the Cassegrain focus of the 3.6 m telescope, using an IR photometer designed at Paris-Meudon Observatory (Epchtein, 1981). The filters were centered at 11.3μ and 20.0μ with a FWHM of 1.3μ and 5.0 μ respectively. The typical integration time for a flux determination was 2 mn. Titan's spectrum between 0.6 and 0.9μ was monitored at the Cassegrain focus of the 1.52 m telescope using the Boller and Chivens spectrograph associated with a Reticon camera. The dispersion was 228 Å/mm and the spectroscopic resolution about 6 Å. The slit was a 2×2 arcsec aperture. The time needed to record one scan was 5 mn. Spectra of Saturn and the sky were recorded after each Titan scan for comparison.

On June 28, the emersion occurred approximately at sunset (21:45 U.T.). Both the IR and the visible experiment suffered from limitations due to the rapid change in sky brightness with time. Significant data were obtained from 22:05 to 25:30 U.T. from the spectroscopic experiment, and between 22:20 and 25:30 U.T. from the IR experiment.

Results

We did not obtain any indication of a variation of the temperatures at 11.5μ and 20μ versus time, and our values were in agreement with previous observations (McCarthy et al., 1980). So the conclusion of the IR observation is that both the temperature of the upper atmosphere of Titan and the surface temperature were not modified during the 4-hour eclipse.

We did not observe any change in the CH_4 bands (6190, 7250, 7950, 8900 Å) either. The equivalent width of the 7250 Å band, located at the maximum sensitivity wavelength, was 68 ± 5 Å and remained constant within the error bars during the whole experiment; this value is in agreement with previous observations (Wamsteker, 1975). This implies that there has been no change in the CH_4 distribution nor in the scattering properties of the atmosphere after a 4 hours eclipse. This implies that the atmosphere is very stable, and that the aerosols of very large thermal inertia probably dominate the energy budget of the upper atmosphere. This is consistent with a thick atmosphere, predominantly composed of nitrogen as suggested by Voyager 1 results. The present set of observations will provide new constraints upon the new model for Titan's atmosphere that will be based on the Voyager data.

Acknowledgement

We thank C. Perrier, J. Veliz and the whole ESO staff for their cooperation in this programme.

References

Epchtein, N. 1981. Thèse de doctorat d'Etat, Université de Paris VII.

Mc Carthy, J. F., Pollack, J. B., Houck, J. R., Forrest, W. J. 1980. *Astrophysical Journal* (in press).

Wamsteker, W. Private communication. 1975.

Upper Limit of the Gaseous CH_4 Abundance on Triton

M. Combes, T. Encrenaz, J. Lecacheux, Observatoire de Paris-Meudon
C. Perrier, ESO, La Silla

Triton, Neptune's largest satellite, has been known for a long time to be able to retain an atmosphere of heavy gases, due to its mass and temperature. Several attempts for detecting the gaseous CH_4 molecule in Triton's spectrum have been inconclusive (Cochran and Cochran, 1977; Cruikshank et al., 1979). In contrast, Benner et al. (1978) reported the identification of a CH_4 gaseous absorption at 8900 Å, as well as Cruikshank and Silvaggio (1979) in the near-infrared; from the second study, an abundance of 7 m-Am (meter-Amagat)* was derived.

A new observation of Triton was recorded on June 28, 1980, at the 1.52 m telescope on La Silla with the Boller and Chivens spectrograph and a Reticon 1024 C camera, in the 6000–9000 Å range. The dispersion was 228 Å/mm, corresponding to a spectroscopic resolution of about 6 Å. The exposure time was 1 hour. The adjacent sky was recorded under the same exposure conditions for comparison. Spectra of the scattered light of the Sun and spectra of Neptune were also recorded for comparison and calibration. The data were degraded to a resolution of 25 Å to improve the S/N ratio (30 at 7250 Å).

There is no trace of CH_4 absorption at 6190, 7250, 7950 and 8900 Å. Using the 7250 Å band which corresponds to the wavelength of maximum sensitivity, the upper limit of equivalent width is 4 Å, which in turn corresponds to an upper limit of 3.5 m-Am for a one-way column abundance of CH_4 on Triton.

Our result is in agreement with the recent result of Johnson et al. (1980) who found from the 8900 Å band an upper limit of 1 m-Am of CH_4 on Triton. The disagreement with Cruikshank and Silvaggio's result might come from true differences in scattering processes in the visible and near-infrared ranges. Additional data are certainly needed in order to reconcile visible and IR observations.

* One meter-Amagat corresponds to a column of gas of 1 m under standard conditions (1 atm. 273 °K).

Acknowledgement

We thank the ESO staff for its cooperation in this programme, and Mr. J. Veliz for his contribution in the data reduction.

References

Cochran, W. D., Cochran, A. L. 1978. *Bulletin of the American Astronomical Society,* **10,** 585.

Cruikshank, D. P., Stockton, A., Dyck, H. M., Becklin, E. E., Macy, W. 1979. *Icarus,* **40,** 104.

Cruikshank, D. P., Silvaggio, P. M. 1979. *Astrophysical Journal,* **233,** 1016.

Johnson, P. E., Greene, T. F., Shorthill, R. W. 1978. *Icarus,* **36,** 75.