ARE MOLECULES RESPONSIBLE FOR ORIGIN OF COLD GIANTS MASS LOSS?

I.K. SHMELD
Radioastrophysical observatory
Latvian Academy of Sciences
Turgeneva 19, 226524 Riga, Latvia

V.S. STRELNITSKIJ, A.V. FEDOROVA O.V. FEDOROVA
Institut for Astronomy Ac.Sci. USSR,
Pjatnickaja 48, 109017 Moscow USSR

ABSTRACT. It is shown that radiative pressure in vibronic transitions of molecules may play an important role in origin of mass outflow of cold giants and supergiants.

The mechanism of mass loss of cold giants is of great interest during last years. It seems that it is hard to explain the mass loss from these stars only as the dust driven winds (A.G. Hearn, 1989), see however (C. Dominik et. al.,1990). Usually some additional mechanisms explaining the initial gas acceleration near the star surface are considered. Most papers deal with different kinds of waves to explaine that (see A.G. Hearn, 1989 for details).

One of the possible additional mechanism may be light pressure on the circumstellar molecules. In the layers near the photosphere the main source of absorption are molecular bands and the integral is reduced to a sum upon the most important molecular bands. According to calculations of chemical equilibrium in the upper atmospheres M-class giants and supergiants all the carbon is tied in the CO molecules and the most of remaining O is in the H_2O molecules. These molecules are characterized by strong rotational-vibrational bands near the peak of photosphere emission and may contribute the major part into radiative acceleration of the gas. Pure rotational transitions also may be important as quasi-continuum absorbers in the 10 - 40μ region (T. Tsuji, 1966). CO vibrational bands have an important role in absorption.

If we assume that inward radiation flux is negligible, then the distribution of radiation intensity is isotropic ($F_\nu = \pi I$) and constant within the i-th vibrational band ($I_{\nu i}$ = const), the most molecules are in the lower state of the vibrational transition, then, if $a_{rad} \simeq a_{grav}$:

P. D. Singh (ed.), Astrochemistry of Cosmic Phenomena, 413–414.

https://doi.org/10.1017/S0074180900090549 Published online by Cambridge University Press

$$\sum_i \frac{n_i}{n} I_{\nu i} f_i + \frac{37.7\, n_{H_2O}}{n} \int k^r_\nu I_\nu d\nu \simeq 4.0 \cdot 10^{-20} \frac{M}{r^2} , \quad (1)$$

where n_i – the number density of molecules in the lower level i, k^r_ν(cm) – the mean extinction coefficient in the quasi-continuum rotational spectrum and f_i – the oscilator strength.

Assuming that the most of molecules are in the ground vibrational state and taking into account only the strongest bands from this state (4 – 6)μ for CO, with f $\simeq 1.1 \cdot 10^{-5}$, 6.3μ and 2.7μ for H_2O, with f $\simeq 1.0 \cdot 10^{-5}$ and $0.9 \cdot 10^{-5}$, in accordance with (1) follows:

$$\frac{n_{H_2O}}{n} \left[I_{2.7} f_{2.7} + I_{6.3} f_{6.3} + 37.7 \int k^r_\nu I_\nu d\nu + \right. \qquad (2)$$

$$\left. + \frac{n_{CO}}{n} I_{4.6} f_{4.6} \simeq 4.0 \cdot 10^{-20} \frac{M}{r^2} \right.$$

We assume for a typical supergiant star $R = 10^{14}$ cm, T_{eff} =3000K, M=10$M_\odot$ and for Mira variable $R = 7 \cdot 10^{13}$cm, T_{eff}= 2000K, $M = 1 M_\odot$. If for I_ν we take the Plank appromaximation, instead of (2) we have:

$$2.5 \frac{n_{H_2O}}{n} + \frac{n_{CO}}{n} \simeq 3.3 \cdot 10^{-3} , \; 2.4 \frac{n_{H_2O}}{n} + \frac{n_{CO}}{n} \simeq 1.3 \cdot 10^{-3} \quad (3),$$

for supergiant and Mira variable correspondingly.

If usual abundances He/H = 0.8, O/H = $0.8 \cdot 10^{-3}$, O/C = $0.3 \cdot 10^{-3}$ are assumtd and if most of the carbon is in the CO and remaining O in the H_2O, then for oxygen stars radiation pressure on molecules may be important only for stars with $M \simeq 10 M_\odot$

For carbon stars all the oxygen is tied in CO one obtains from (3), for $a_{rad} \simeq a_{grav}$ O/H $\simeq 4 \cdot 10^{-3}$ for a supergiant, O/H $\simeq$ $2 \cdot 10^{-3}$ for a Mira variable) and C/H $\simeq 3 \cdot 10^{-4}$($M/M_\odot$) for both.

The radiative pressure on the carbon bearing molecules may initiate the gas outflow from the massive carbon stars.

REFERENCES

C. Dominik et. al., (1990) Astron. and Astroph., **240**., 365.
A. G. Hearn. (1989) in: "From Miras to Planetary Nebulae: which Path for Stellar Evolution" – Proc. of International Colloqium. Sept. 4–7. Montpellier France.
T. Tsuji (1966) Publ. Astron. Soc. Jap., **18**, N3, 127.