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SUBDWARFS AND ABSORPTION DUE TO QUASI-MOLECULAR HYDROGEN

By M. S. Vardya

Tata Institute of Fundamental Research, Bombay, India

A quasi-molecule of two colliding hydrogen atoms in the unstable $^3\Sigma_u^+$ state goes to the excited $^3\Sigma_g^+$ state, with the absorption of light. The free-bound absorption continuum produced by quasi-H_2 was considered as early as 1947 by Wildt[1] and found to be unimportant in late-type stars. Recent work by Erkovich[2] suggested that this source of opacity may in fact be astrophysically important (see *e.g.* Zwaan[3]). The work of Soloman[4] and of Doyle[5] showed, however, that Erkovich cross-sections have been overestimated by about two orders of magnitude. Hence, the absorption due to quasi-H_2 is negligible compared to H^- and H in stars with chemical composition similar to that in the solar photosphere. However, Varsavsky[6] has recently suggested that absorption due to quasi-H_2 may not be negligible in subdwarfs, which have rather low metal abundance. We have tried in this note to examine the role of quasi-H_2 in metal-deficient stars.

We have assumed that the relative abundance of metals is similar to that in the solar photosphere[7], with the ratio of metal to hydrogen being one-hundredth that in the Sun, and the ratio of helium to hydrogen, by number, being 0·0625. We have used the absorption cross-sections for quasi-H_2 as given by Soloman[4] and have followed Vardya[8] for the continuous opacity due to H, H^-, H^-_2, He and He^-. The relevant range in pressure for a given temperature can be obtained from the work of Swihart and Fischel[9].

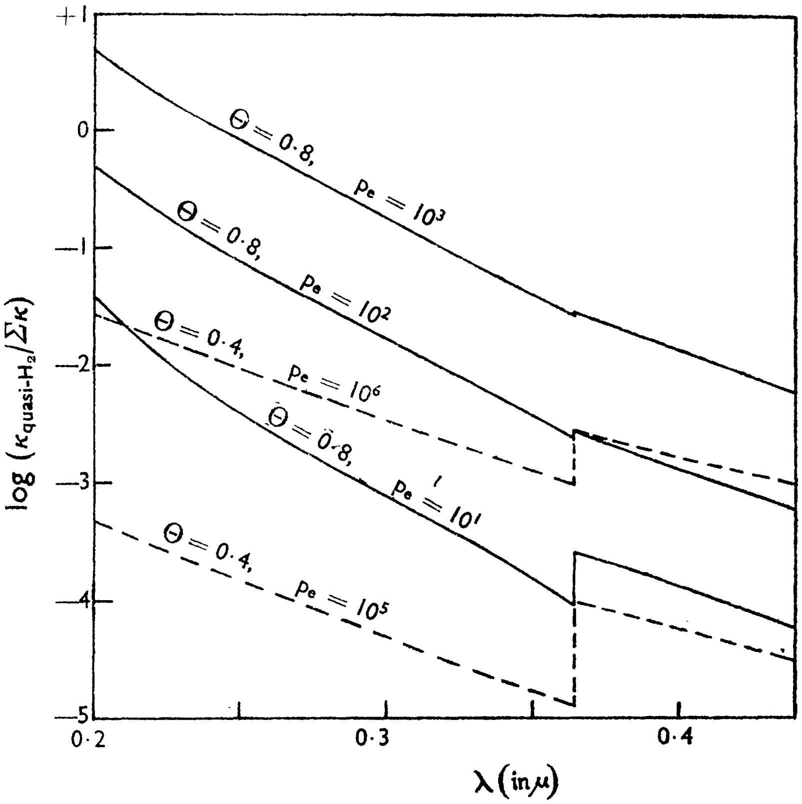

Fig. 1

Logarithm of the ratio of absorption due to quasi-H_2 to sum of other sources of continuous opacity as a function of wavelength.

Table I gives the values of $\theta = 5040{\cdot}39/T$ (where T is the absolute temperature), electron pressure, p_e, and the corresponding gas pressure, P_g, at which comparisons have been made of the relative importance of quasi-H_2 absorption to other sources of continuous opacity. (P_g and p_e are in dyn/cm².)

Table I

θ	p_e	P_g	θ	p_e	P_g
0·4	10^5	$7{\cdot}0 \times 10^5$	1·2	10^{-1}	$1{\cdot}5 \times 10^5$
0·4	10^6	$5{\cdot}1 \times 10^7$	1·2	10^1	$9{\cdot}9 \times 10^7$
0·8	10^1	$7{\cdot}6 \times 10^3$	1·6	10^{-2}	$1{\cdot}3 \times 10^5$
0·8	10^2	$7{\cdot}6 \times 10^5$	1·6	10^0	$4{\cdot}6 \times 10^7$
0·8	10^3	$8{\cdot}5 \times 10^7$			

Fig. 1 is a plot of $\log_{10} (\kappa_{\text{quasi-}H_2}/\Sigma\kappa)$ versus λ (wavelength in μ) for $\theta = 0{\cdot}4$ and 0·8 and Fig. 2 is a similar plot for $\theta = 1{\cdot}2$ and 1·6. Here $\Sigma\kappa$ is the sum of the continuous absorption coefficients due to H, H^-, H^-_2, He and He^-. These curves indicate that the importance of quasi-H_2 absorption, compared to other sources of opacity in the ultra-violet region of subdwarfs, increases as one proceeds from high temperatures to low temperatures, reaches a maximum around $\theta \simeq 1{\cdot}2$, and then its importance decreases. The effect of metal abundance, for a given (θ, P_g), is rather small at high temperatures, because there most of the electrons are donated by hydrogen and atomic hydrogen is the main source of opacity. In fact, the ratio $\kappa_{\text{quasi-}H_2}/\kappa_H$, where

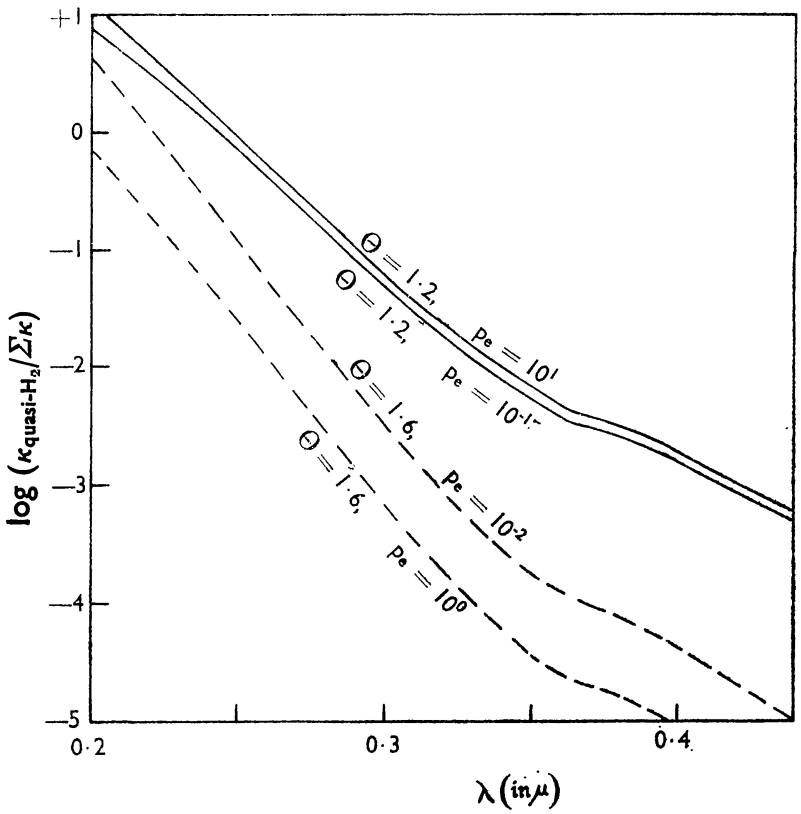

FIG. 2

Logarithm of the ratio of absorption due to quasi-H_2 to sum of other sources of continuous opacity as a function of wavelength.

κ_H is the absorption coefficient due to atomic hydrogen, is independent of metal abundance. At lower temperatures, where the metals donate most of the electrons, the importance of quasi-H_2 is greatly enhanced with decrease in metal abundance, as is evident from a comparison of our figures with those of Soloman[4]. It is the increasing formation of molecular hydrogen that reduces the relative importance of quasi-H_2 absorption as one proceeds to values of θ beyond $\theta \simeq 1{\cdot}2$. Needless to say, the importance of quasi-H_2 absorption decreases with decrease in hydrogen to metal ratio. Though quasi-H_2 is important in subdwarfs, it should not be forgotten that, in the ultra-violet region of these stars, Rayleigh scattering is very important in redistributing radiation.

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