N87-15081

Observational discrimination between modes of shock propagation in interstellar clouds: predictions of CH^+ and SH^+ column densities in diffuse clouds

D. R. Flower
Physics Department
The University
Durham DH1 3LE (U.K.)

G. Pineau des Forets and E. Roueff
DAPHE
Observatoire de Paris
F-92195 Meudon Principal (France)

T.W. Hartquist
MPI fur extraterrestrische Physik
D-8046 Garching bei Munchen (F.R.G.)

Considerable effort in recent years has been devoted to the study of shocks in the diffuse interstellar medium. This work has been motivated partly by the observations of rotationally excited states of H_2 (Spitzer et al. 1973; Spitzer and Cochran 1973), and partly by the realisation that species such as CH^+, OH and H_2O might be formed preferentially in hot, post-shock gas (Elitzur and Watson 1980). The problem of CH^+ and the difficulties encountered when trying to explain the high column densities, observed along lines of sight to certain hot stars, have been reviewed by Dalgarno (1976).

The importance of a transverse magnetic field on the structure of an interstellar shock was demonstrated by Draine (1980) and Draine, Roberge and Dalgarno (1983). Transverse magnetic fields above a critical strength give rise to an acceleration zone or precursor, in which the parameters of the flow vary continuously. Chemical reactions, which change the degree of ionisation of the gas, also modify the structure of the shock considerably (Flower, Pineau des Forets and Hartquist 1985; Draine and Katz 1986).

Very recent work by ourselves (Pineau des Forets et al. 1986) and by Draine (1986) has shown that large column densities of CH^+ can be produced in magnetohydrodynamic shock models. Shock speeds $u_s \approx 10$ km s^{-1} and initial magnetic field strengths of a few μG are sufficient to produce ion-neutral drift velocities which can drive the endothermic C^+ (H_2,H) CH^+ reaction. These authors have also shown that single-fluid hydrodynamic models do not generate sufficiently large column densities of CH^+ unless unacceptably high shock velocities

($u_s \approx 20$ km s^{-1}) are assumed in the models. Thus, the observed column densities of CH^+ provide a constraint on the mode of shock propagation in diffuse clouds. More precisely, they determine a lower limit to the ion-neutral drift velocity.

A similar study of the sulphur chemistry behind shocks in diffuse clouds (Pineau des Forets, Roueff and Flower 1986) has lead to similar conclusions regarding the column density of SH^+, which is produced through the endothermic $S^+(H_2,H)SH^+$ reaction. Column densities $N(SH^+) > 10^{12}$ cm^{-2}, which should be observable in absorption in the near ultraviolet region, are produced only when the maximum ion-neutral drift velocity $|u_i-u_n|_{max} > 5$ km s^{-1}. Detection of these lines, whose predicted equivalent widths are given in the Table, should provide valuable information on the transverse magnetic field strength in the vicinity of the shock.

			W_λ (mÅ)				
Line	λ (Å)	f_{line}	log N=9.18	11.79	12.76	12.99	13.11
$R_{11}(0)$	3363.49	6.2 10^{-4}	9 10^{-5}	0.04	0.35	0.60	0.80
$^RQ_{21}(0)$	3339.97	4.6 10^{-4}	7 10^{-5}	0.03	0.26	0.44	0.58
$^SR_{21}(0)$	3336.64	3.7 10^{-4}	6 10^{-5}	0.02	0.21	0.36	0.47

References

Dalgarno, A. 1976, in Atomic Processes and Applications, eds. P.G. Burke and B.L. Moiseiwitsch (Amsterdam: North Holland), p.109.

Draine, B.T. 1980, Ap. J., 241, 1021.

Draine, B.T. 1986, Ap. J., in press.

Draine, B.T., and Katz, N.S. 1986, Ap. J., in press.

Draine, B.T., Roberge, W.G., and Dalgarno, A. 1983, Ap. J., 264, 485.

Elitzur, M., and Watson, W.D. 1980, Ap. J., 236, 172.

Flower, D.R., Pineau des Forets, G., and Hartquist, T.W. 1985, M.N.R.A.S., 216, 775.

Pineau des Forets, G., Flower, D.R., Hartquist, T.W., and Dalgarno, A. 1986, M.N.R.A.S., in press.

Pineau des Forets, G., Roueff, E., and Flower, D.R. 1986, M.N.R.A.S., submitted.

Spitzer, L., Drake, J.F., Jenkins, E.B., Morton, D.C., Rogerson, J.B., and York, D.G. 1973, Ap. J., 181, L116.

Spitzer, L., and Cochran, W.D. 1973, Ap. J., 186, L23.