SASP
SYMPOSIUM ON ATOMIC
AND SURFACE PHYSICS

JANUARY 17-23, 1988
LA PLAGNE - FRANCE

ORTHO-PARA TRANSITIONS IN INTERSTELLAR MOLECULAR HYDROGEN

D. GERLICH
Albert Ludwigs Universität
Fakultät Für Physik
Hermann Herder Strasse 3
D-780 Freiburg
Federal Republic of Germany

E. ROUEFF
DAMAP
Observatoire de Meudon
F92195 Meudon principal cedex
France

ABSTRACT

The interpretation of the observed columm densities of molecular Hydrogen into the first eight rotational levels requires a detailed analysis of the different excitation processes. Radiative pumping and collisional excitation lead only to even ΔJ transitions. We study in this paper the implications of recent calculations on the ortho-para transition of molecular Hydrogen due to reactive collisions with protons in a comprehensive model of diffuse interstellar clouds.

The observations of several rotational excited levels (up to J = 7) in cold diffuse interstellar clouds /1/ should be good indicators of the typical conditions prevailing in these regions such as the density, temperature, and the UV radiation field. A single excitation temperature cannot explain the various observations and one needs a detailed description of the different excitation mechanisms. Black and Dalgarno /2/ have shown that radiative pumping followed by UV fluorescence in the Lyman and Werner band systems and subsequent radiative cascades have to be considered as well as collisional excitation by H, H2, e^-, H^+ of the ground vibrational rotational states.

Amongst all these processes, reactive collisions with H^+ arising from the cosmic ray ionization properties are the only which induce odd ΔJ transitions between rotational states of H2 i.e. ortho-para conversion.

Let us remind however that molecular Hydrogen is formed on grains which leads to a certain statistical distribution on rovibrational states of H2 which is subsequently modified by the above mentioned processes.

Comprehensive models of diffuse interstellar clouds have recently been completed /3/ under the assumption of a H2 $(J=1)+H^+ \rightarrow H2\ (J=0)+H^+$ rate coefficient of 3 10^{-10} cm^3 s^{-1} from the estimation of Dalgarno et al /4/. They used the further assumption that :

$k_{J+2 \rightarrow J+1} = g(J+1) / g(J+2)\ k_{J+1 \rightarrow J}$ where g is the statistical weight of J level.

We study in this paper the subsequent changes in the various rotational column densities of H2 when one includes more realistic data which were obtained from a most dynamically biased (MDB) statistical theory of the reactive process /5/.

Table 1 gives the column densities in log (cm^{-2}) relevant to the diffuse Zeta Ophiuchi cloud. Observation are reported in Viala et al /3/. VRA refers to results obtained with the physical conditions of model 6 in table 6 of Viala et al (1987) using as the standard radiation field the Mathis et al /6/ expression (column M83 of table 8 same reference). These calculations are performed with the reaction rate coefficients estimations reported in /2/ and /4/. GR column refers to the results obrained within the same physical conditions but with the recent calculation of Gerlich /5/ for the $\Delta J=1$ transition rate coefficients of H^++H2 (J) reaction.

	Observations	VRA	GR
H	20.72 ± 0.03	20.64	20.68
H2	20.65 ± 0.08	20.69	20.67
H2 J=0	20.51 ± 0.08	20.52	20.30
J=1	20.10 ± 0.08	20.19	20.42
J=2	18.56 + 0.10, -0.19	18.52	18.54
J=3	17.07 + 0.30, -0.39	16.98	16.88
J=4	15.68 + 0.10, -0.19	14.96	14.98
J=5	14.63 ± 0.05	14.22	14.25
J=6	13.69 ± 0.05	13.43	13.46
J=7	13.55 ± 0.05	13.13	13.21

Comparison between VRA and GR shows that the new data on ortho-para transitions by Gerlich /5/ modify consideratly the J=0 and J=1, column densities of H2. Higher rotational states which are mainly populated through radiative pumping and subsequent fluorescence are almost not affected. However, larger transitions can occur in $H^{+}+H_2(j)$ reactions.Preliminary calculations show that $\Delta J=2$ and $\Delta J=3$ transitions have reasonnable probability. We shall present the implications of these transitions at the conference in the frame of the same model. An astrophysical discussion on the physical parameters describing the interstellar Zeta Ophiuchi cloud will then be relevant.

REFERENCES

/1/ SPITZER L., MORTON W.A., 1976, Astrophys. J. **204**, 731

/2/ BLACK J.H., DALGARNO A., 1976, Astrophys. J., **203**, 132

/3/ VAN DISHOEK E.F., BLACK J.H., 1986, Astrophys. J. suppl[t] **62**, 116
VIALA Y.P., ROUEFF E., ABGRALL H., 1987, Astron. Astrophys. in press

/4/ DALGARNO A., BLACK J.H., WEISHEIT J.C., 1973, Astrophys. letters **14**, 77

/5/ GERLICH D., 1982, SASP Meeting **3**, 304

/6/ MATHIS J.S., METZGER P.G., Panajia, N. 1983, Astron. Astrophys. **128**, 212.