

Ultraviolet-excited High Rotational Level Molecular Hydrogen in Interstellar Clouds: Models and Observational Results

Dae-Hee Lee¹, Soojong Pak¹
and Ewine F. van Dishoeck²

¹Korea Astronomy & Space Science Institute,
Daejeon 305-348, S. Korea
email: dhlee@kasi.re.kr

²Sterrewacht Leiden,
Postbus 9513, 2300 RA LEIDEN *The Netherlands*

Abstract. We have calculated 2448 interstellar cloud models to investigate the formation and destruction of high rotational level H₂ according to the combinations of five physical conditions: the input UV intensity, the H₂ column density, cloud temperature, total density, and the H₂ formation rate efficiency. The models include the populations of all the accessible states of H₂ with the rotational quantum number $J < 16$ as a function of depth through the model clouds, and assume that the abundance of H₂ is in a steady state governed primarily by the rate of formation on the grain surfaces and the rates of destruction by spontaneous fluorescent dissociation following absorption in the Lyman and Werner band systems (Black & van Dishoeck 1987). The high rotational levels $J = 4$ and $J = 5$ are both populated by direct formation into these levels of newly created molecules, and by pumping from $J = 0$ and $J = 1$, respectively. The model results show that $N(4)/N(0)$ and $N(5)/N(1)$ are proportional to the incident UV intensity, as predicted by Jura (1975), and are linearly decreased with the logarithm of molecular fraction, $\log f$.

Also, recent observational results are discussed with reference to the calculated models. Twenty-four high resolution spectra of H₂ in the LMC and SMC (Tumlinson et al. 2002), and three translucent clouds (Sonnentrucker et al. 2002; Sonnentrucker et al. 2003; Rachford et al. 2001), observed by FUSE, provide an appropriate data set to examine the models. We have surveyed 54 early-type stars in the Galactic disk and halo with the Berkeley Extreme and Far-Ultraviolet Spectrometer (BEFS), part of the ORFEUS telescope, to obtain interstellar H₂ absorption spectra for this research. The observed high rotational H₂ level line ratios are well followed in the models, so that we can estimate the densities of the clouds from the models.

Keywords. ISM: lines and bands, ISM: clouds, ultraviolet: ISM

References

- Jura, M. 1975, *ApJ* 197, 581
Black, J. H., & van Dishoeck, E. F. 1987, *ApJ* 322, 412
Rachford, B. L. et al. 2001, *ApJ* 555, 839
Sonnentrucker, P., Friedman, S. D., Welty, D. E., York, D. G., & Snow, T. P. 2002, *ApJ*, 576, 241
Sonnentrucker, P., Friedman, S. D., Welty, D. E., York, D. G., & Snow, T. P. 2003, *ApJ*, 596, 361