ORTHO-PARA CONVERSION IN COLLISIONS OF H_2 WITH H_2

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Molecular hydrogen is the main constituent of the atmospheres of the giant planets, Jupiter, Saturn, Uranus, and Neptune. The relative abundances of ortho- and parahydrogen are inferred from infrared emission spectra of the S(1) and S(0) quadrupole transitions near 17 and 28 μ, sampling conditions in the stratosphere and upper troposphere [1,2]. At most altitudes and latitudes the ortho/para ratio is not in statistical equilibrium at the local temperature, interpreted as resulting from vertical transport from lower hotter or colder regions. Modeling atmospheric circulation requires a quantitative understanding of the rates and mechanisms of ortho-para conversion, which appears to take roughly 30 to 100 years.

The two candidate mechanisms are collisions with paramagnetic aerosols and with the weak magnetic moment of ortho-H_2. The better known mechanisms involving ions or H atoms or 4-center atom exchange are inoperative at the relevant low altitudes and low temperatures. An important constraint on atmospheric models could be provided by a quantum mechanical treatment of nuclear spin coupling in collisions of ortho-H_2 with ortho-H_2 and para-H_2. The only estimate in the literature [1] is based on scaling the magnetic moments of H_2(J=1) and O_2, which suggests a ortho-para conversion probability of about 4×10^{-19} and a rate coefficient of about 1×10^{-28} cm^3 s^{-1}.

We will discuss the expected hamiltonian operators involving nuclear spin, procedures for evaluation of matrix elements, and dynamics approaches. Especially interesting are ideas about virtual excitation of the $b^3\Sigma_u^+$ state resulting in ortho-para coupling through nuclear-spin/electron-spin hyperfine interaction [3,4].

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