# The $H_3^+ + H_2$ reaction; a possible mechanism for *para*-$H_3^+$ enrichment in the diffuse interstellar medium

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$H_3^+$ plays a dominant role in the chemistry of the interstellar medium (ISM) due to its abundance and reactivity. Because of its ubiquity, $H_3^+$ has also been used as a probe of density and temperature conditions in these regions. Observations of *para*- and *ortho*-$H_3^+$ fractions along diffuse sightlines such as $\zeta$ Per, X Per, HD 229059, and Cyg OB2 12 (to name a few) indicate a temperature that is on average 30-40 K lower than that measured by the comparison of *para*- and *ortho*-$H_2$ fractions. This implies a *para*-$H_3^+$ enrichment by processes that are not well understood. One possible explanation is a spin change due to the reaction $H_3^+ + H_2 \rightarrow H_2 + H_3^+$, which proceeds by one of two mechanisms. These mechanisms can drive different *para* and *ortho* fractions as governed by the nearly rigorous conservation of intrinsic nuclear spin, and their relative rates have been experimentally shown to have a strong temperature dependence. Our recent spectroscopic measurements of hydrogenic plasmas at temperatures similar to those found in diffuse interstellar clouds indicate that the observed *para*-$H_3^+$ enrichment could be the result of these temperature dependent processes. Understanding the details of the fundamental $H_3^+ + H_2$ reaction at cold temperatures has important implications with regards to $H_3^+$ as an astrophysical probe, and the chemistry of both $H_3^+$ and $H_2$ in the ISM.

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