Study of the He$\mu + H_2$ Reaction at Room Temperature: Theory and Measurement

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Muonic helium He$\mu$ is a neutral species with the composition $\alpha^{++}\mu^-e^-$ which can be regarded as a unique heavy H-atom isotope with mass 4.1 amu. It extends the range of H-atom isotopes for the study of kinetic isotope effects from Mu to He$\mu$, a remarkable factor of 36 in mass.

We have begun kinetics studies of the reaction

$$\text{He}^\mu + H_2 \rightarrow \text{He}^\mu H + H \quad (2)$$

as a complement to the earlier study [1] of Mu + H$_2$ → MuH + H, which is a seminal reaction with precisely-calculated potential energy surfaces [2].

We here present a preliminary reaction rate constant for reaction (1) measured at 295 K, as well as variational transition state calculations of the same. The figure shows both results, with a measured rate $k = 4.1 \pm 0.7 \times 10^{-16}$ cm$^3$s$^{-1}$ and a calculated value of $2.46 \times 10^{-16}$ cm$^3$s$^{-1}$. Despite the large uncertainty in these initial measurements, there appears to be a discrepancy, perhaps indicating more tunneling in the reaction than the VTST calculations account for.

![Fig. 1: Reaction rates for the He$\mu + H_2$ reaction measured (points and solid fitted line) and calculated (dashed line) at 295 K.](image)