Abstract Submitted
for the DAMOP15 Meeting of
The American Physical Society

The molecular quantum rotor in cold reactions at the Langevin universal limit YUVAL SHAGAM, AYELET KLEIN, Weizmann Institute of Science, Israel, WOJCIECH SKOMOROWSKI, Universität Kassel, Germany, RENJIE YUN, VITALI AVERBUKH, Imperial College London, UK, CHRISTIANE KOCH, Universität Kassel, Germany, EDVARDAS NAREVICIUS, Weizmann Institute of Science, Israel — Fast chemical reactions have been predicted to be solely governed by long-range interactions as was established by Langevin in 1905. The theory has become central to astrochemistry, where fast chemical processes dominate, giving rise to collision energy scaling laws of reaction rates, such as $E^{1/6}$ for the van der Waals interaction. Importantly, for molecular reactants, the presence of additional anisotropic long-range interactions, such as quadrupole-quadrupole, is predicted to surface only when the molecule is rotationally excited, changing the scaling law to $E^{1/10}$. Although molecular reactions with near unit probability have been observed at ultra-cold temperatures, these scaling laws and the role of the rotational state remain unconfirmed experimentally. We report the direct observation of universal scaling laws in chemi-ionization reactions of H_2 and HD by $He(2^3P_2)$ extending over three orders of magnitude in collision energies. For rotationally ground-state HD molecules the rate follows the $E^{1/6}$ scaling, while for H_2, where the majority of the molecules are rotationally excited, the scaling changes to $E^{1/10}$ at low collision energies only. At the lowest collision energies the Wigner threshold laws start governing the reactions as the classical Langevin theory breaks down.

Yuval Shagam
Weizmann Institute of Science, Israel

Date submitted: 29 Jan 2015 Electronic form version 1.4