Researchers see unexplained phase shifts during atomic scattering

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In an article published today (Thursday, Aug. 24) in the American Physical Society journal *Physical Review Letters*, researchers reported observing unexpected instantaneous phase shifts during atomic scattering.

By firing a proton beam at atoms, investigators can observe the dynamics resulting from the interactions between the various particles in the system. In the journal article, the researchers describe how when a hydrogen molecule and a proton collided, they observed unexpected features related to the wave nature of the particles. The work builds on the ongoing exploration into the "few-body problem" in physics, which emerges with three or more interacting particles.

"When we studied two-center interference patterns occurring in the reaction probabilities for proton-hydrogen collisions, we identified that there were unexpected shifts in the interference fluctuations," says Dr. Michael Schulz, Curators' Distinguished Professor of physics at Missouri University of Science and Technology and one of the principle investigators in the journal article. "That means that, apart from the electronic symmetry in the hydrogen molecule which can explain such a phase shift in other systems, there appear to be other causes that can lead to a phase shift in the interference term."

Atomic particles can act as waves in certain situations, similar to the waves of an ocean. When waves overlap, interference effects can result and lead to large changes in the reaction probabilities. The unexpected phase shift observed in the interference structure means that there is still a lack of understanding of the collision dynamics at the atomic level, even for relatively simple systems containing only three or four particles.

"For a relatively simple system such as a proton colliding with an atom or a molecule, for which existing models were thought to provide an adequate description, we continue to uncover very surprising discrepancies between theory and experiment," says Schulz, who is also the director of Missouri S&T's Laboratory for Atomic, Molecular and Optical Research.

This is the first time that fully differential cross sections for capture have been measured when accompanied by vibrational fragmentation of the hydrogen molecule, Schulz says. These cross sections have revealed that phase shifts in atomic scattering amplitudes are not as well understood as once thought.

"Further research is definitely needed, so that we can continue to investigate the few-body dynamics in atomic collision systems," says Schulz.

More information: Fully Differential Study of Capture with Vibrational Dissociation in p+H2 Collisions. *Phys. Rev. Lett.* 119, 083402 – Published 24 August 2017
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