Eberhard Tiemann
(Universität Hannover)

Mass scaling, Born-Oppenheimer correction and other isotope effects for cold molecules and cold collisions

Modeling ultracold matter from atomic or molecular ensembles needs highly reliable interaction potentials, which are defined by the Born-Oppenheimer approximation. For performing calculations for different isotope combinations regular mass scaling of the mechanics within potentials is assumed. This assumption is a direct outcome of the Born-Oppenheimer approximation and thus the quality is limited by the order of the electron-to-atom mass ratio. The precision of up to date measurements within ultracold ensembles is reaching the limit where the Born-Oppenheimer approximation might be no longer justified. This talk will discuss this situation and give molecular examples where extensions are clearly needed and how successful the theoretical description presently is. The mass scaling not only assumes that the Born-Oppenheimer approximation is valid, but also that the isotope effects are solely depend on the atomic or nuclear masses. But changing the isotope in a molecule might also significantly change the charge distribution within the nucleus, thus the Coulomb interaction will change, which is not covered by any corrections to the Born-Oppenheimer approximation. We will discuss the magnitude of this effect, called field effect or volume shift in atomic physics, and describe situations where such isotope effect will be distinguishable from the normal mass effect. Does this play a role within the field of ultracold ensembles?

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Universität Ulm, Raum 45.2.304
Albert-Einstein-Allee 45 (Uni West), 89081 Ulm

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