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Young-type interference in collisions between Helium and molecular Hydrogen ions

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The dissociative electron transfer from He into slow diatomic molecular ions was measured in a kinematically complete experiment by using cold target recoil ion momentum spectroscopy (COLTRIMS) in combination with a high resolution molecular fragment imaging technique. The electron transfer leads to neutral molecules in highly excited electronic states which dissociate in a second step of the reaction. With COLTRIMS we determine the energy which is taken from the motion of the projectile and transferred to internal degrees of freedom of the molecule. Furthermore we are able to determine the kinetic energy release (KER) of the dissociation as well as the spatial orientation of the molecular break up. When using H_2^+ as projectiles this enables us to select the direct population of the lowest dissociative state of H_2 $b^3\Sigma_u^+$ from the measured data. This reaction channel was analyzed in an inverse kinematics scheme where the molecule is regarded as two closely lying scattering centers at which an incoming He wave scatters. The orientation and the distance of these two scattering centers are obtained by detecting the fragments after the reaction, as the internuclear vector can be determined using the reflection as well as the axial recoil approximation. We find a striking double slit interference pattern in the transverse momentum transfer between the He atom and the molecule which we can modulate by selecting different internuclear distances (i.e. KERs) in our offline analysis. Compared to an optical double slit, the interference's minima and maxima are swapped. The latter is the result of a phase shift in the electronic part of the wave function.