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Similarities in fragmentation dynamics of molecules under various perturbations

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Synopsis We show experimentally, by interpretation of coincidence multiparticle momentum maps, that the evolution of an unstable molecular ion to an asymptotic many-body state occurs via pathways that are independent of the mechanism of formation of the molecular ion.

Fragmentation of molecules by charged particle or photon-induced ionisation is largely understood as the evolution of a molecular ion along a potential hypersurface towards an asymptotic state consisting of two or more charged and neutral fragments. For diatomic molecules, the evolution is adequately described by one kinematic parameter, the kinetic energy release. For triatomics the situation is more complicated, but ion-ion coincidence techniques based on time-of-flight mass spectrometry have been able to reveal the dynamics to a large extent. Three-fold coincidences, with full momentum mapping gives complete correlated dynamics for triatomics, including that of the neutral partner. Investigations going beyond triatomics and to charge states higher than 3 face several challenges. We take the case of fragmentation of triply charged SF₆, formed by subjecting SF₆ to 170 eV photoabsorption and 5 MeV/u C⁵⁺ ion impact, under single collision conditions. The correlated momentum distributions of two F⁺ ions, for fragmentation channels in which the third ion is of type SF_m⁺ ($m = 0 \dots 3$), in the two cases are shown alongside. While there are differences in the intensities of the various channels, the *distributions* in the momentum maps are remarkably similar. Coupled with the analysis of the momentum distribution of the correlated partner SF_m⁺ and residual neutral, if any, we come to similar conclusions about the dissociation pathways stemming from the two perturbations. This is clear evidence for the model of fragmentation in which ionisation is followed by dissociation along a potential energy hypersurface, the latter being independent of the mechanism of formation of the molecular ion state.

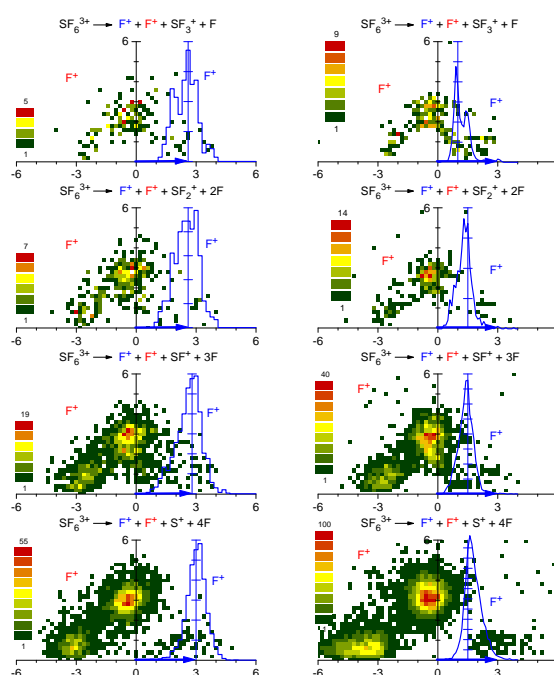


Figure 1. Correlated momentum distributions of two F⁺ ions in various fragmentation channels of triply ionised SF₆ via photoabsorption (*left panel*) and ion impact (*right panel*). The direction of the momentum vector of the first F⁺ ion in the coincidence is taken as the *x* axis. The *x* and *y* axis scales are in units of 10⁻²² kg·m/s.

References

- [1] R K Kushawaha *et al*, *J Phys B* **43** 205204 (2010)
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