The Life, Death and Knockout of Interstellar Carbon

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Polycyclic aromatic hydrocarbons (PAHs) and fullerenes, two families of carbon-based molecules, both present in the interstellar medium, have since the 1980's been of particular interest for astrophysicists. The existence of PAHs in space was proposed at that time [1][2], but the first unique species was not discovered until 2021 [3]. Fullerenes – the most well-known fullerene being the large, football-shaped C_{60} molecule – were first observed in experiments [4] and later also in space [5]. Their interstellar presence aside, these two types of molecules have in common that they provide unique insights into knockout processes that lead to them losing individual carbon atoms in energetic collisions.

To further understand the creation and longevity of such "imperfect" molecules, we collided C_{60} and PAH coronene respectively with He atoms and studied the remaining products. This was done experimentally at the DESIREE facility, colliding 30 keV C_{60} molecules with stationary He atoms, as well as by simulation, using the LAMMPS molecular dynamics software. In both experiment and simulation, in the C_{60} as well as the coronene case, we saw that it is possible for C_{59} and PAH knockout fragments to be created - this was known from previous experiments [6], but they had so far only been shown to survive on microsecond timescales. While our simulations show the creation rate and early stages of the C_{59} and PAH fragments, our experiments show that the fragment population has cooled down significantly on a 10 ms timescale and remain stable thereafter [7][8]. Thus, we conclude that it is possible for such molecules to survive indefinitely in the gas phase.

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