# In search of evidence of plasmon excitation in PAHs at low-energy electron impact

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**Synopsis** Plasmon excitation in polycyclic aromatic hydrocarbons (PAHs) is well established for fast charged particles, but it has so far been inferred only indirectly, from statistical fragmentation patterns. We report the first successful attempt to extract the effects of plasmon excitation in PAHs under electron impact at energies comparable to the plasmon energy (about 17 eV).

Plasmon (collective) excitations are coherent oscillations of the delocalized, less tightly bound electrons of a system. They appear in metal clusters, graphite, fullerenes and polycyclic aromatic hydrocarbons (PAHs), and even in nuclei [1,2]. In a plasmon, the electron density oscillates collectively relative to the positive ionic background, giving rise to a characteristic plasmon frequency [1,2]. Plasmon excitation has a very large cross section, and its oscillator strength is much greater than one, which is itself a signature of a collective excitation [3]. A plasmon resonance occurs when the energy deposited matches this characteristic energy and drives it into a higher energy state. Depending on the energy retained it either decays by autoionization [1,2] or if it is high enough, it redistributes the excess energy over all the vibrational modes of the ion, which then dissociates statistically [1,3].

Charged particles can transfer a wide range of energies in a single collision, and their strong electric fields give rise to large ionization cross sections [1] when compared to the case of photoionization. For planar aromatic molecules the plasmon peak lies at about 17 eV [1,2] with a half-width of about 7–8 eV [2], and the photoionization cross section is about 22 Mb per carbon atom [4].

Plasmon excitation by fast charged particles has been studied by colliding high energy protons with naphthalene. The yields of $H$ and $C_2H_2$ loss stayed nearly constant as the proton energy changed, and a comparison with photon-induced breakdown curves indicated an energy deposition of about 18 eV and attributed to plasmon excitation [2].

In this work, we measured the yields of the fragment ions of azulene and naphthalene (both $C_{10}H_8$) as a function of electron impact energies around the plasmon resonance energy. Each yield curve was smoothed and differentiated. For azulene, the derivatives of the $H$-loss ($C_{10}H_7^+$, m/z 127) and $C_2H_2$-loss ($C_8H_6^+$, m/z 102) channels, which are linked to plasmon decay [3], peak at about 17 eV with a spread of about 6–7 eV, close to the plasmon energy and width of PAHs [2]. The derivative of the $2H/H_2$-loss channel ($C_{10}H_6^+$, m/z 126) peaks well above the plasmon energy range, pointing to a different excitation process. Furthermore, a similar treatment of other fragmentation channels reveal more complex behavior. These aspects are being explored in the context of fundamental charged particle interactions with molecules and its astrophysical implications.

## References

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