PAH destruction and formation processes in HII complexes

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This work is devoted to evolution of polycyclic aromatic hydrocarbons (PAHs) and carbonaceous grains in HII complexes. Observations indicate that strength of PAH emission correlates with metallicity and hardness of the interstellar radiation field (ISRF) in HII complexes and also varies from young to old objects. The goal of the work is to trace an evolution of the PAH abundance and emission in HII complexes at different values of metallicity, the ISRF intensity and hardness and to determine the most relevant processes responsible for variations in PAH parameters. We consider the most significant processes, namely, – photodestruction of PAHs, aromatisation of carbonaceous grains, destruction by the most abundant ions (H, He, C) and electrons, fragmentation due to collisions between grains.

The major role is played by a destruction of PAHs by an intense ultraviolet ISRF inherent to HII complexes. A bombardment of PAH surface by photons leads to a gradual destruction of PAHs through a dissociation of hydrogen atoms and acetylene groups. The efficiency of the dissociation depends on properties of ISRF and sizes of PAHs and can be estimated for typical parameters of HII complexes. Small PAHs (up to 50 carbon atoms in a skeleton) are completely destroyed in HII complexes with typical ultraviolet component of ISRF while larger molecules survive.

Along with the PAH destruction process of PAHs by strong UV field, they can also be produced due to transformation of carbonaceous grains from an aliphatic structure to an aromatic one (in other words, their aromatisation) under the influence of ultraviolet photons. Small grains (~ 10Å) may be fully restructured at an evolutionary time scale of an HII complex, and, thus, number of PAHs increases. Aromatisation of larger grains within a few millions years can only be significant in their outer layers, but a spectrum of a large grain with an aliphatic core and aromatic envelope will have aromatic features in the IR range as well.

Shock waves related to the expansion of HII regions inside a complex can accelerate ions up to relatively high velocities (> 50 km/s). Collisions between a PAH molecule and energetic ions may result in a destruction of a PAH molecule through a direct ejection of a carbon atom from a skeleton at a nuclear interaction or dissociation of a C_2 fragment at an electronic interaction. Also collisions of PAHs with fast electrons can be crucial at high temperatures. At temperatures higher than 10^4 K this process begins to play a role and becomes the most important when massive stars explode.

Apart from processes of grain interaction with energetic photons, ions and electrons, larger impacts, grain-grain collisions, can occur in interstellar medium and in HII complexes as well. Depending on a strength of a shock wave and grain velocities these collisions may lead to redistribution of grain sizes. Specially, number of small grains including PAHs can grow at the expense of shattering of large carbonaceous grains.

All these processes are put together to model the evolution of PAHs/small grains at different physical parameters of HII complexes. Kinematical velocities of grains and ions are determined using gas-dust dynamic model. Theoretical magnitudes in infrared bands corresponding to Spitzer and Herschel detectors are calculated and compared with observations of extragalactic HII complexes.