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CAN STELLAR ROTATION SHAPE THE PLANETARY NEBULAE?

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We present a new scenario for bipolar PNe formation based on the effects of the stellar rotation on the stellar radiation field. We suggest that in the early stages of the evolution of a planetary nebula, its central star increases its rotational velocity and, due to the gravitational darkening or a possible formation of an equatorial disk, creates a bipolar ionization structure in the expelled spherical AGB shell.

The reaction of a spherical shell to an axisymmetric radiation field is explored, and we show that the shell is ionized in a bipolar pattern. This is not the fully developed bipolar nebula, but a structure formed in the very early stages of the post-AGB evolution. We speculate that the nuclear region of an AGB star is contracted at the end of the thermonuclear reactions. This stellar remnant partially conserves its angular momentum and increases its rotational velocity by about 2 orders of magnitude. Thus, the proto-CSPN first has axisymmetric radiation field due to the gravitational darkening, and then its wind is axisymmetric. The radiation field forms a bipolar structure which eventually evolve to a typical bipolar nebula. The proposed idea is based on the observed characteristics of the B[e] stars among which are several CSPN (Lamers & Cassinelli 1999).

The 3D photoionization models are performed using Cloudy_3D (Morisset 2006). The CSPN luminosity seen by the nebula depends on the polar angle and is close to 3000 $L_\odot$ in the polar direction. The gas density is constant, set to 30000 H/cm^3. The inner radius of the nebula is 10^{16} cm, the total size of the nebula being 3.6×10^{16} cm in the polar direction (maximum extension). We tested the idea using two models. (1) We calculated the reaction of the spherical nebula to the radiation of a star without wind but with gravitational darkening. Gravity darkening predicts that the flux from the star at given latitude is proportional to the local effective gravity. Thus the flux at the equator is reduced and the temperature of the radiation is lower. The resulting axisymmetric radiation ionizes the polar regions but keeps the equatorial regions cold and recombined. (2) The second model considers a star similar to the B[e] stars for which we used our code Astaroth (Georgiev et al. 2006; Zsargó et al. 2006). The presence of the disk alters the radiation field of the star even more than the gravitational darkening. Figure 1 shows the radiation field of the star with disk-like wind. As in the first model, the polar regions of the nebula are ionized and the equator is kept neutral.

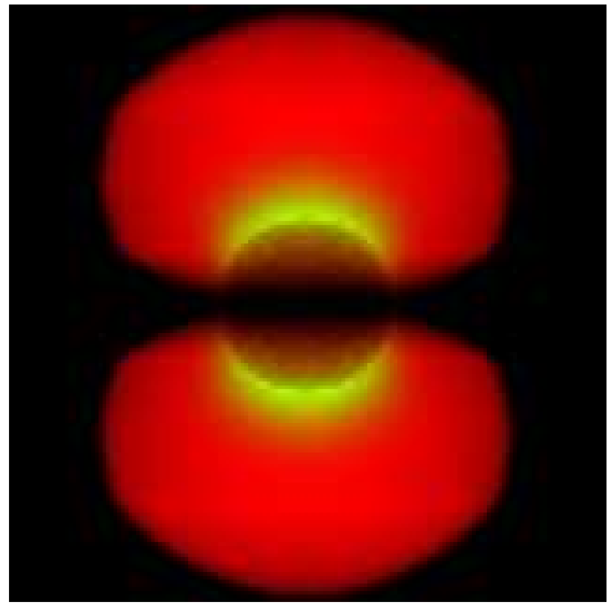

Fig. 1. Flux at different polar angles for Model 2. The radiation field is a calculated with 2D radiation transfer code Astaroth. The changes in the flux are result of the ionization structure of the wind.

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