COMMON ENVELOPE EVOLUTIONS OF BINARY SYSTEM AND FORMATION OF PLANETARY NEBULAE

Izumi Hachisu: Department of Physics and Astronomy, Louisiana State University and Department of Aeronautical Engineering Kyoto University
Mariko Kato: Department of Astronomy, Keio University

The more massive component star evolves faster than the less massive one. When it fills its inner critical Roche lobe at the red-giant stage or at the asymptotic-giant-branch (AGB) star stage, the mass transfer begins from the more massive to the less massive component. Since the separation decreases with the mass being transferred, the more massive component star eventually overfills its outer critical Roche lobe. The mass outside the outer critical Roche lobe flows out of the system and the outgoing matter carries away the orbital angular momentum. As a result, the separation of the binary shrinks and the size of the outer critical Roche lobe drops. This shrinkage of the Roche lobe enhances the systemic mass outflow. This process is almost dynamically unstable because the deep convective envelope responses the loss of the envelope mass in an almost dynamical time scale. This dynamical process will stop when most of the hydrogen-rich envelope of the more massive component is lost and its radius becomes less than the radius of the outer critical Roche lobe.

The matter outside the outer critical Roche lobe is accelerated by the gravitational torque and gets the outward velocity, which was estimated by Sawada, Hachisu, and Matsuda (1984) to be about one third or one fourth of the orbital velocity of binary.

Three typical models of binary planetary nebula formation are calculated. After spiral-in, a small amount of hydrogen-rich envelope remains on the white dwarf surface ($<10^{-3}$ $M_{\odot}$). The time scale of the nuclear burning depends mainly on the white dwarf mass. If the white dwarf mass is 0.6 $M_{\odot}$, its elapsed time until the extinction of the hydrogen-shell burning is about 10^{4} yr.

	Model 1	Model 2	Model 3
initial masses	1 $M_{\odot}$ + $(1+\alpha)M_{\odot}$	1 $M_{\odot}$ + $(1+\alpha)M_{\odot}$	1 $M_{\odot}$ + 2 $M_{\odot}$
separation	300 $R_{\odot}$	1000 $R_{\odot}$	1200 $R_{\odot}$
white dwarf mass	0.45 $M_{\odot}$ (He)	0.6 $M_{\odot}$ (C+O)	0.8 $M_{\odot}$ (C+O)
orbital period	10 day	100 day	3 day
nebula mass	0.5 $M_{\odot}$	0.4 $M_{\odot}$	1.2 $M_{\odot}$
separation	30 $R_{\odot}$	100 $R_{\odot}$	10 $R_{\odot}$
time scale	7×10^{5} yr	1×10^{4} yr	2×10^{3} yr
outward velocity	10-30 km/s	10-20 km/s	10-40 km/s

REFERENCES

Sawada, K., Hachisu, I., and Matsuda, T. 1984, N. N. R. A. S., **206**, 673.

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