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Transonic galactic outflows in a dark matter halo with a central black hole

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Abstract. We study fundamental properties of transonic galactic outflows in the gravitational potential of a cold dark matter halo (DMH) with a central super-massive black hole (SMBH) assuming an isothermal, steady and spherically symmetric state. Transonic solutions of galactic outflows are classified according to their topological features. As result, we find two types of transonic solutions distinguished by a magnitude relationship between the gravity of DMH and that of SMBH. The loci of transonic points for two types are different; one transonic point is formed at a central region (< 0.01kpc) and another is at a very distant region (> 100kpc). Also, mass fluxes and outflow velocities are different for two solutions. Thus, these solutions may differently influence the evolution of galaxies and the release of metals into the intergalactic space.

Furthermore, we apply our model to the Sombrero galaxy. In this galaxy, the wide-spread hot gas is detected as the trace of galactic outflows while the star-formation rate is low, and the observed gas density distribution is similar to the hydrostatic state (Li *et al.* 2011). To solve this discrepancy, we propose a solution that this galaxy has a slowly accelerating outflow; the transonic point forms in a very distant region (~ 120 kpc) and the wide subsonic region spreads across the stellar distribution. Thus, the gas density distribution in the observed region is similar to the hydrostatic state. Such slowly accelerating outflows are different from high-velocity outflows conventionally studied (Igarashi *et al.* 2014).

However, this isothermal model requires an unrealistically large mass flux. Then, we apply the polytropic model to this galaxy incorporating mass flux supplied by stellar components. We find that it can reproduce the observed gas density and the temperature distributions with the realistic mass flux. Thus, our polytropic model successfully demonstrates the existence of the slowly accelerating outflow in the Sombrero galaxy (Igarashi *et al.* 2015).

Keywords. galactic winds, evolution of galaxies, chemical enrichment, hydrodynamics

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