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Study of radiatively driven outflows around black holes under hydrodynamic and relativistic regime

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Abstract. We investigate relativistic fluid jets driven by radiation from a shocked accretion disc around a non-rotating black hole and study the effects on jet dynamics due to associated parameters like accretion rate, magnetic pressure in the disc, composition *etc*..

Keywords : ISM: jets and outflows – radiation mechanisms: general – black hole physics – hydrodynamics

1. Introduction and analysis

Extending previous non relativistic study (Kumar et al. 2014), we use hybrid disc (Chakrabarti and Titarchuk 1995; Mandal and Chakrabarti 2008) that contains thermally emitting Keplerian disc (KD) sandwiched by sub-Keplerian disc (SKD).The post shock disc (PSD), along with synchrotron and bremsstrahlung emission (similar to SKD), inverse-Comptonizes the radiations from SKD and KD. We treat jet to originate close to the black hole and expand spherically under radiation and thermal driving. Relativistic equation of motion in steady state are obtained as

$$\gamma^4\vartheta\left(1-\frac{a^2}{\vartheta^2}\right)\frac{d\vartheta}{dz}=\frac{2\gamma^2a^2}{z}-\frac{1}{2(z-1)^2}+\frac{(2-\xi)\gamma^3}{f+2\Theta}[(1+\vartheta^2)\mathcal{F}-\vartheta(\mathcal{E}+\mathcal{P})] \quad (1)$$

with $f=(2-\xi)\left[1+\Theta\left(\frac{9\Theta+3}{3\Theta+2}\right)\right]+\xi\left[\frac{1}{\eta}+\Theta\left(\frac{9\Theta+3/\eta}{3\Theta+2/\eta}\right)\right]$ and $\vartheta, \gamma, a, z, \xi$ being velocity, Lorentz factor, sound speed, jet distance and ratio of protons and electrons respectively (Chattopadhyay and Ryu 2009; Ryu et al. 2006). $\mathcal{F}$, $\mathcal{E}$ and $\mathcal{P}$ are radiative flux, energy and pressure (Chattopadhyay et. al. 2004; Chattopadhyay 2005; Vyas et al. 2015) respectively that vary with accretion rate $\dot{m}$, ratio of magnetic pressure to the gas pressure β and disc geometry. After solving eq. (1), we obtain solutions for ϑ profile of the jet and study its dependence on above parameters.

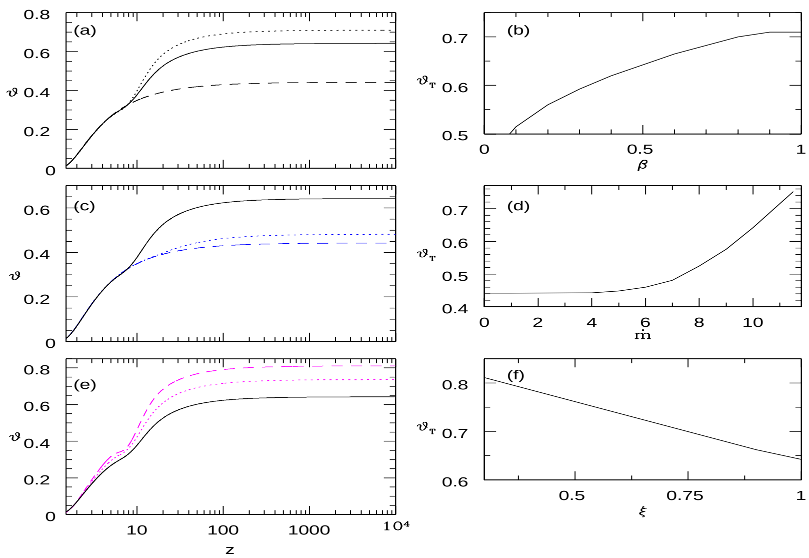

Figure 1. Dependence of jet velocity profile and terminal speeds ϑ_T on disc parameters.

2. Results and conclusions

Fig 1.(a), (c) and (e) show variation of ϑ with z. In 1(a), $\beta = 1.0$ (dotted, black online), 0.5 (solid, black online) and 0.0 (dashed, black online). Similarly in 1(c) $\dot{m} = 1.0$ (dashed, blue online), 7 (dotted, blue online) and 10 (solid, black online) and 1(e) shows ϑ profiles with the ratio of protons and electrons ξ in the jet with $\xi = 1.0$ (solid, black online), 0.6 (dotted, magenta online) and 0.3 (dashed, magenta online). Corresponding figures in right column show the effects of these parameters on the terminal velocity ϑ_T (ϑ when $z \to 10^4$ Schwartzchild radius). The jet speed increases by increasing β, $\dot{m}$ and decreasing ξ (see, Figs. 1 b, d and f).

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