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Estimation of the mass outflow rates around rotating black holes

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Abstract. We consider steady, advective, rotating, inviscid accretion disc around the spinning black holes to compute the mass outflow rate ($R_{\dot{m}}$) defined as the ratio of mass flux of outflowing to the inflowing matter. Due to centrifugal barrier, accreting matter suffers discontinuous shock transition and because of shock compression, the post-shock matter becomes hot and denser than the pre-shock matter. We call the post-shock disc as Post Shock Corona (PSC). During accretion, a part of the inflowing matter deflects as bipolar outflows due to the presence of excess thermal gradient force at PSC. We find that $R_{\dot{m}}$is directly correlated with the spin of the black hole (a_k) for the same set of inflow parameter, namely specific energy ($\mathcal{E}$) and specific angular momentum (λ). We observe that the maximum outflow rate($R_{\dot{m}}^{max}$) weakly depends on spin (a_k) that lies in the range$\sim$ 17% - 18% of the inflow rate.

Keywords : accretion, accretion discs – black hole physics – shock waves - ISM: Jets and outflows

1. Introduction

Powerful Jets and outflows are commonly observed in accreting black hole system. In this work, we attempt to study the mechanism of outflow generation from the vicinity of spinning black hole and for that we adopt the pseudo-Kerr effective potential Chakrabarti and Mondal (2006) that successfully mimics the space-time geometry around the rotating black hole. Inflowing matter with appropriate input parameters, such as, $\mathcal{E}$ and λ, encounter centrifugal barrier that triggers the discontinuous transition of flow variables when the Rankine-Hugoniot shock conditions (Landau and

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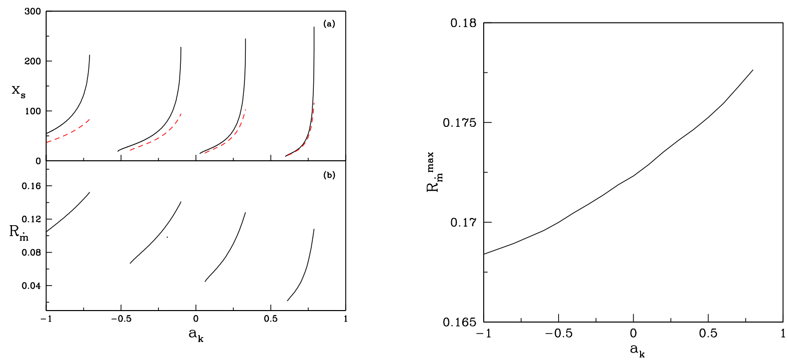

Figure 1. Left panel: (a) Variation of shock location (x_s) with a_k. Here, $\mathcal{E}$ = 0.002 and λ = 2.8, 3.28, 3.6 and 3.92 (right to left). Solid and dashed curves represent the result in absence and presence of $R_{\dot m}$. (b) ($R_{\dot m}$) with a_k corresponding to (a). **Right panel**: Variation of maximum outflow rate ($R_{\dot m}^{max}$) with a_k. We use adiabatic index $\gamma = 4/3$ for all cases.

Lifshitz (1959)) are satisfied. In order to calculate the mass outflow rate, we consider the outflow geometry as described in Molteni et al. (1996). We follow the solution procedure as described in Aktar et al. (2015) to calculate the outflow variables and avoid repetition.

2. Results and Discussion

In the left panel of Fig. 1, we show the variation of shock location (x_s) and the corresponding mass outflow rate ($R_{\dot m}$) with a_k where we choose $\mathcal{E}$ = 0.002 and λ = 2.8, 3.28, 3.6 and 3.92 (right to left). Solid and dashed curves indicate the variation of shock location without and with mass loss respectively. For the same set of $\mathcal{E}$ and λ, the shock location moves away from the black hole horizon with the increase of spin a_k. This indicates that the size of the post-shock region (PSC) is increased with the increase of spin a_k and the inflowing matter is deflected by the large effective area of PSC that eventually produces more outflow. Right panel of Fig. 1 represents the maximum outflow rate $R_{\dot m}^{max}$ as a function of a_k where we find that $R_{\dot m}^{max}$ weakly depends on a_k.

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