Indian J Phys. **76B (1)**, 7–10 (2002)

I J P B
an international journal

Hydrodynamic interaction between an accretion flow and a strong wind around a black hole

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Received 9 July 2001, accepted 2 November 2001

Abstract Outflows in a black hole environment necessarily emerge from the accretion flow When the outflow is very strong it interacts with the accretion flow and can affect the inflow pattern As a result of this non-linearity, accretion flow develop instability which is a complex form of the shear instability (Kelvin-Helmholtz Instability) In a time dependent numerical simulation using Smoothed Particle Hydrodynamics method we demonstrate this instability and show that this instability is present independent of whether cooling process is turned on or not We also show that the effect is not symmetric with respect to the equatorial plane.

Keywords . Accretion disks, black hole physics, hydrodynamics

PACS Nos. 97.10 Gz, 04.70 -s, 67.55.Fa

1. Introduction

Identification of black holes requires a thorough understanding of the physical processes around them (See [1,2] for recent reviews). In particular, the behaviour of accretion flows decides the behaviour of the radiation that is emitted from the flow. Molteni *et al* [3], using a Smoothed Particle Hydrodynamics method [4] showed that adiabatic accretion flows form standing axisymmetric shocks roughly at the theoretically predicted place. Subsequently, cooling process was added and Molteni *et al* [5] showed that in this case standing shocks oscillate producing oscillation of X-rays from the accretion flows when certain resonance conditions are satisfied. In both the simulations, strong outflows were generated from the post-shock region.

Meanwhile, Pringle [6] pointed out that in presence of radiative force by the radiation emitted from the inner part of a disk, the outer edge may be warped and subsequent follow-up of the work by Maloney *et al* [7] suggested that the apparent warping of the disk around NGC4258 might be due to this process. Generically speaking, any outgoing force, on an initially perturbed flow would exert a torque on the flow and would tend to rotate the disk. Molteni *et al* [3] found that a significant outflow, roughly 15–20% of the inflow, could be produced in an axisymmetric disk accretion, but since the simulation was constraint to be axisymmetric as well as symmetric with respect to the equatorial plane, the torque on the accretion flow could not be observed. However, if some of the constraints as mentioned above were removed, then the interaction of the outflowing wind and the accretion could be studied and the growth of warping due to shear instability could be verified. Some of the results of warping behaviour have been presented in Molteni *et al* [8].

In the present Rapid Communication, we demonstrate that the outgoing wind and the incoming accretion flow interact non-trivially and as a result, the disk geometry is changed substantially. In the next Section, we present the results of the numerical simulation. We show that the conclusion we draw is generic and the results are valid even

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