MODELS OF STEADY THICK ACCRETION DISCS AROUND A SCHWARZSCHILD HOLE *

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ABSTRACT. An outline is given of a project to model thick accretion discs around a black hole. A simple shear viscosity is assumed and the effects of radiation transport and thermal conduction neglected. Preliminary results are given for the equatorial structure of the model discs.

1. INTRODUCTION

Accretion onto a black hole differs in at least two important respects from accretion onto white dwarfs and neutron stars. Firstly, the black hole has no hard surface, so there is no guarantee that the potential energy of the infalling matter will ultimately be dissipated by viscous forces and radiated away. This makes plain the need for a dissipation mechanism which is efficient enough to account for the observed luminosities of active nuclei without postulating an unreasonably high rate of infall.

The second difference is that the poloidal velocity of the fluid, as measured by a co-rotating observer, is necessarily supersonic as it crosses the event horizon. Models of black hole accretion discs which, following the standard thin disc recipe, assume a subsonic poloidal velocity therefore ignore possible dissipative mechanisms - particularly multiple shocks - in the supersonic region.

Also, as Bondi (1952) pointed out in one of the pioneering works on stellar accretion, the condition that a flow pass through a sonic point removes one degree of freedom from the set of possible flow parameters. If the ambient conditions at infinity are specified, it is not in general possible to impose an arbitrary mass flux and obtain a steady solution. The value of the flux, in other words, is an eigenvalue of the problem. This is true for spherical accretion in the Schwarzschild metric (Michel, 1972), and for the equatorial plane of an inviscid, polytropic disc with rotation (Abramowincz and Zurek, 1981; Lu, 1984a,b).

* Discussion on p.424

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2. THE MODEL DISCS

The author is presently engaged on a project which aims to generalise the work referred to above to include thick discs with viscosity, in both the Schwarzschild and Kerr metrics. For simplicity, the only contribution to the viscous stress tensor is assumed to be rotational shear. Heat conduction and radiative transfer are assumed to have negligible effect on energy transport in the disc, and the fluid is taken to be non-self-gravitating and to have a polytropic equation of state.

When complete, it is hoped the analysis will yield the shape of the disc surface, the locus of sonic points, the run of specific angular momentum through the disc, and the maximum possible efficiency for a given viscosity law. (The maximum efficiency is taken to be the maximum value of the specific energy in the disc.)

So far, models of equatorial flows in the Schwarzschild metric have been constructed which match onto the axisymmetric Newtonian thick disc solutions due to Gilham (1981) at infinity. The specific angular momentum diverges as the square root of the radial co-ordinate at infinity, and drops to less than 4GM/c at the event horizon (where M is the mass of the hole). In all the models investigated to date, the sonic point is located at between 1.2 and 1.5 Schwarzschild radii. However, work by Abramowicz and Zurek (1981) suggests that there may be a family of discs with sonic points located tens of Schwarzschild radii from the event horizon. The best maximum efficiency achieved so far is 1.5%, but this is anticipated to increase to about 6% as the full range of the parameters is explored.

Further work will extend the analysis away from the equatorial plane, and to the full Kerr metric.

3. REFERENCES

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