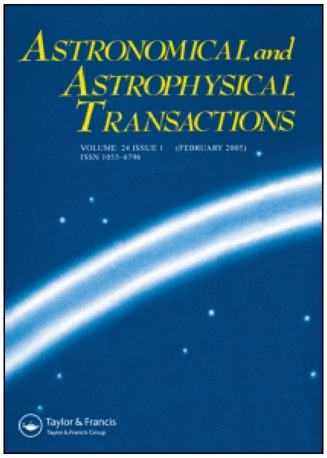

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Instability of spherical accretion with a shock wave on to a point mass

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INSTABILITY OF SPHERICAL ACCRETION WITH A SHOCK WAVE ON TO A POINT MASS

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The stability problem for a standing shock wave in an accretion flow on to a Newtonian point mass is considered. The linear perturbations are taken in the form $e^{i\omega t}Y_{lm}$, where ω is the frequency of the perturbations and l is the wavenumber of spherical harmonics. The eigenvalue describing the stability properties is determined by the finitness of the perturbed parameters of the flow at the sonic point. The shock front is unstable against radial perturbations for any adiabatic index $1 < \gamma < 5/3$ and for any distance between the shock front and the sonic point. If this distance exceeds some critical value the mode $l = 1$ also becomes unstable.

KEY WORDS Accretion, hydrodynamic instabilities, shock waves

The stabulity of a shock wave in the accretion adiabatic flow is investigated in the framework of linear analysis. The unperturbed flow is steady-state and is described by the analytical Bondi solution (1952). The main difficulty of the stability problem for a shock wave is connected with the correct statement of the bondary conditions at the centre of accretion where the unperturbed flow has a singularity. For example, Stellingwerf and Buff (1978), who studied the stability of shock-free Bondi accretion, used arbitrary inner boundary conditions.

However, the problem of the stability of a shock wave can be formulated correctly, if there is a transition through a sonic point in the postshock flow. This situation is possible either for non-adiabatic critical flow (Chang and Ostriker, 1985) or for adiabatic supercritical flow, for which we have to rule out the condition that the gas is at rest at infinity. In this latter case the gas has to infall at supersonic velocity at infinity. The stability problem is thus reduced to an eigenvalue problem for the finite interval between the shock front $R_{\rm sh}$ and the sonic point r_s. The perturbed parameters of the flow are taken in the form $e^{-i\omega t}Y_{lm}$, where ω is the frequency of perturbations and l is the wavenumber of spherical harmonics. External boundary conditions are obtained from the linearized conditions at the perturbed shock front. The requirement for the perturbation to remain finite provides the inner boundary condition at the sonic surface. The frequency spectrum for $\gamma = 4/3$

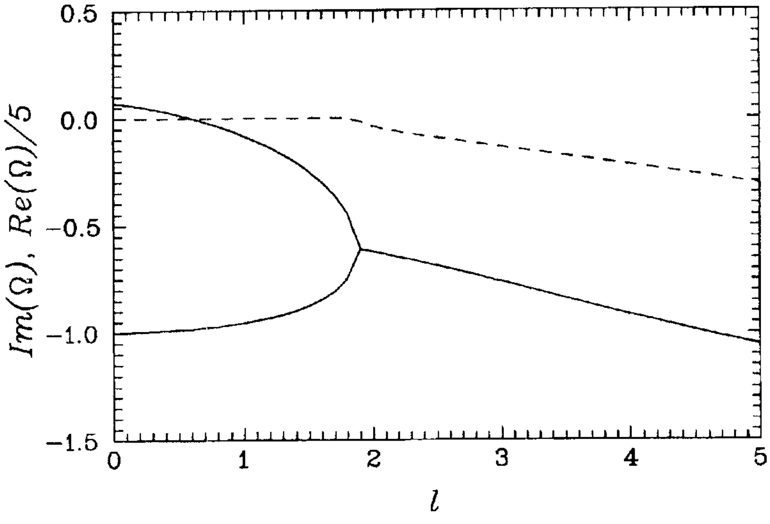

Figure 1 Image (solid line) and real (dashed line) parts of the dimensionless frequency $\Omega = \omega R_B/|u_+|$, where $R_B = Gm/u_\infty$ is the Bondi radius, u_+, u_∞ are the unperturbed velocities just behind the shock front and at infinity, respectively, as a function of wave number l for $\gamma = 4/3$ and $R_{\rm sh}/r_s = 1.1$.

and $R_{\rm sh}/r_s = 1.1$ is plotted in Figure 1. The dispersion curve reveals instability of the shock front against radial perturbation. This instability exists for any adiabatic index $1 < \gamma < 5/3$ and for any distance between the shock front and the sonic point. For $R_{\rm sh}/r_s > 2.5$ the mode $l = 1$ becomes unstable as well.

The instability of the shock wave in an accretion flow is caused by a local instability of the shock front. It makes itself evident, because the perturbation is concentrated just behind the shock front. This accounts for the fact that the inner boundary conditions have little influence on the structure of the perturbed postshock flow. So, we have serious reasons to suppose that the shock front is unstable even if the preshock flow is critical and there is no transition through the sonic point in the postshock flow.

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