AGN ACCRETION DISKS WITH FINITE TURBULENT PRANDTL NUMBER

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The present paper reports results of a study of turbulent energy transport in AGN accretion disks. We follow the spirit of the papers by Shakura et al. and Rüdiger et. al in which the concept of an eddy heat conductivity was introduced and developed. For the viscosity we use a standard α- description with the main component of the stress tensor $t_{r\phi}$ proportional to the gas pressure. The dimensionless Prandtl number Pr given as the ratio of turbulent kinematic viscosity and turbulent heat conductivity enters the model as a free parameter. The disk structure depends sensitively on material properties such as opacities and specific heats. In our calculations we have used an equation of state and mean opacities taking into account a list of the most important ionization processes as well as the radiation contributions to thermodynamic quantities. Here are our main conclusions:

- There is a broad range of parameters where turbulent energy transport is of utmost importance.In particular turbulent energy transport is much more efficient than the radiative one in hydrogen ionization zones and in regions with high radiation pressure dominance. The latter fact might seem suprisingly but is caused by the strong radiative contribution to the specific heat c_P. In general we found a flattening of the temperature profile and a steepening of the density profile with almost complete removal of density inversions due to turbulent transport.
- We have calculated surface density- surface temperature relations for various values of α and Pr. In H- ionization zones the value of Pr is of great influence on the shape of this relation. While for $Pr = \infty$ it has the usual S- shape, more complicated structures with the possible occurrence of double S- shapes are found for Pr=O(1).
- Turbulent energy transport changes the shape of the disk. In general an efficient turbulent transport decreases the disk height h. This can lead to a concave disk shape in which irradiation of outer disk parts by inner ones is possible.The height decreasing effect of turbulent energy transport is of great importance for the innermost region of disk models near the Eddington limit. We have calculated a model with $M_{bh} = 10^6 M_\odot$ and L/L_{edd}=0.9 in which a decrease of h by a factor of 3 occurs when Pr is changed from ∞ to 1/3. Thus turbulent energy transport does not resolve but considerably weakens the problem of disk thickening.

References

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