LINE EMISSION FROM ACCRETION DISKS IN ACTIVE GALACTIC NUCLEI

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1. INTRODUCTION

If accretion disks are present in AGN and extend to large radii they should contribute substantially to the Broad Line emission. The outer regions of the disk are indeed illuminated by a small amount of ionizing radiation. X-rays are emitted by the central inner region near the black hole, and they are either received directly by the outer disk, owing to its "flaring" shape (Cunningham, 1976), or partly reflected towards the disk by a hot Compton thin medium (Begelmann and McKee, 1983). X-ray photons are also produced through the Inverse Compton mechanism in compact radio sources located above the disk("jet model").

Collin-Souffrin (1987) suggested that the disk emission could be identified with the intense "Low Ionization Line" spectrum of AGN, consisting of the bulk of Balmer lines and continuum and FeII emission. We explore here this possibility in a quantitative way. We first study the structure of the disk under the assumption of an external illumination. Then using a grid of photoionization computations involving the large range of physical parameters necessary for this problem, we compute line strengths and line profiles emitted by the accretion disk, under different hypothesis for the illuminating non thermal flux.

Note that this study is limited to Seyfert galaxies, where accretion disks are not self-gravitating.

2. DISK STRUCTURE

If the disk is illuminated by an external radiation flux, its structure is modified in the region where this flux dominates he gravitational viscous dissipation. At small radii the disk is optically thick and the incident flux is dissipated in the photosphere. At large radii the disk is optically thin, and has an almost constant temperature close to 10^4K, typical of photionized gas. One has to compute the spectrum emitted by the optically thin region of the disk as well as that emitted by the external radiatively heated layers of the optically thick region.

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3. LINE EMISSION

We have developed a simplified code computing the spectrum emitted when a thick dense shell is illuminated by an external continuum extending from the visible to the hard X-ray range. We applied this code to produce a grid of models (Collin-Souffrin and Dumont, 1988). We show in particular that for large column densities ($\geq 10^{24}cm^{-2}$) and large densities ($\geq 10^{10}cm^{-3}$) the emitted spectrum depends neither on the column density nor on the density.This is fortunate since these conditions are achieved in the outer layers of the optically thick region as well as in the bulk of the optically thin region.So we can use our grid to get functional dependences of the line and continuum intensities on the non thermal flux at the surface of the shell which we parametrize as a function of the radius. It allows us to integrate line emission over the disk radius, and to find line strengths and line profiles for a given radial variation of the external flux.

We assume that the external flux is due either to a central source located at different heights above the disk, or to central radiation scattered by a hot medium. This last assumption corresponds to a flux proportional to R^{-a} ,where a can vary from 2 to 3.

4. RESULTS

We show that:

1. the disk emits mainly low ionization lines
2. for a large range of physical parameters including different bolometric luminosities, masses and accretion rates, and a small amount of radiation returning to the disk (1-10%), the emitted spectrum is quite intense and constitutes a predominant contribution to these broad lines
3. contrary to a common idea, the profiles are not systematically two peaked, but display a wide range of shapes and widths.

Some physical parameters are strongly constrained. For instance,in the case of the jet model, too intense Paschen and Balmer continua follow from too small a distance of the non thermal source to the black hole: for a luminosity of 10^{44}ergs/s the distance should be larger than 10^{-2}pc. Also to avoid too much line emission the fraction of the non thermal flux emitted by the jet should be small (<10%).

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