RED GIANT WINDS AS EMISSION LINE CLOUDS (BROAD OR NARROW) IN ACTIVE GALACTIC NUCLEI

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1. INTRODUCTION

It is proposed that the clouds thought responsible for the line emission in AGN are not of uniform density but stratified. Such a stratification may be a result either of their self-gravity or of gas dynamics associated with each cloud (e.g. winds). To fix ideas we assume the latter possibility, we examine the consequences and compare with the observations and the phenomenology of emission line clouds.(For the general properties of these clouds see review by Netzer in this volume). Given the successes of the standard model the reader may wonder why is there any need for revisions. The reasons are given in detail elsewhere (see also Scoville and Norman this volume). In brief these are the drag of clouds though the confining medium, the excessive accretion rates implied by the standard model, the response of the line radiation to changes in the continuum, and the lack of a dynamical mechanism for cloud formation. Finally, in the "standard" picture the narrow line clouds are a distinct population with separate dynamics and origin.

2. THE MODEL

The basic premise of the model is that the clouds are stratified and in particular that this stratification is the result of gas dynamics i.e. that their density $n(R) \propto R^{-2}$ (R is the distance from the center of the cloud while r denotes the distance from the continuum source) i.e. a density profile appropriate for winds. The winds are assumed to originate in red giants in a star cluster surounding the central source, in order to maximize the cross section of the clouds. The fundamental property of such a stratified cloud is that it will automatically choose the proper value of the ionization parameter demanded by observation. This is because the X-ray radiation from the central engine evaporates the the part of the wind with the densities lower than n_*; this is the density at which the ionization parameter of the gas is Ξ_c^* . All higher densities (the interior of the wind) will be at a temperature $T \simeq 10^4$K and $\Xi < \Xi_c^*$ producing line radiation in agreement with observation. Assuming a mass loss in the wind which is independent of the distance r

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from the continuum source and equal to 10^{-6} $M_{\odot}$/yr, one can easily derive the following scaling laws: If $R_{\star}$ is the radius of the wind corresponding to the density $n_{\star}$ (i.e.the radius of the cloud) and L the luminosity of the central source then

$$R_{\star}/r \propto L^{-\frac{1}{2}} \text{ or } R_{\star} = 7\ 10^{13}\ r_{18} L^{-\frac{1}{2}} \text{ cm} \quad \text{and } N_H(R_{\star}) = 4\ 10^{22}\ L^{-\frac{1}{2}}\ r_{18}^{-1} \text{ cm}^{-2}$$

where $N_H(R_{\star})$ is the column density of the cloud. These values are quite close to the "standard" values quoted for the broad line clouds and depend only on $\dot{m}^{\frac{1}{2}}$ so they are not very sensitive to the values of this parameter. In addition the above relations give us scaling laws that allow one to estimate the values of these quantities as a function of luminosity of distance from the continuum source. Hence clouds in the narrow line region should have $r \sim 10^{20}$ cm and therefore density $n \sim 10^5$ cm^{-3}, column density $N_H \sim 4\ 10^{20}$ cm^{-2} and since their motion is gravitationally induced, a velocity dispersion 10 times smaller than that of BLC; such values are in fact in agreement with observations. This model is hence quite economical in its assumptions since the same concept can accomodate both kinds of clouds (as well as all those in intermediate radii).

The assumptions built into the model so far make it quite concrete and allow the inference of certain correlations which can be tested against observation. We shall examine some of them:

a. The velocity dispersion density correlation: The garvitational origin of the cloud velocities implies $v^2 \propto 1/r$ while the demand of a constant Ξ implies $n(R_{\star}) \propto r^{-2}$. Combining these two relations one gets $v \propto n^{\frac{1}{4}}$. Such a relation can be tested by plotting the dispersion velocity of forbidden lines as a function of their critical density (Fillipenko and Halpern 1984; Whittle 1985); so far the limited existing data appear to be in agreement with this model though more observations are needed. If proven correct such correlation will allow the mapping of the dynamics in the vicinity of the black hole and will thus maybe allowing an independent estimate of its mass.

b. The L(CIV)-L(1350 Å) relation: Wamstecker and Colina (1986) have found that upon variation of the continuum luminosity at 1350 Å, the flux of the CIV line was proportional to L(1350) up to a limiting luminosity L_1 and constant for $L(1350)>L_1$. The model can naturally account for such a relation if one considers that the solid angle subtended by a cloud $(R_{\star}/r)^2 \propto 1/L$ and also that the central source is surrounded by a stellar cluster of radius r_1. The luminosity L_1 is then identified with the luminosity at which the radiation from the continuum source "breaks through" the surrounding clouds at radius r_1.

Finally we only mention the succesful account of the column density - luminosity relation, of the line response to variations in the continuum and the logarithmic emission line profiles by this model.

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