THEORETICAL NARROW EMISSION-LINE PROFILES OF ACTIVE GALACTIC NUCLEI

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In recent years, a large number of high resolution observations of active galactic nuclei (AGN) have become available. Most of them show the [OIII]5007 line profile (Heckman, Miley and Green 1984, Vrtilek and Carleton 1985, Whittle 1985a,b).

Composite models, which account for both shock and ionizing radiation effects on the emitting cloud, are very successful in explaining the observed narrow emission-lines of AGN (Viegas-Aldrovandi and Contini 1988, and references therein). In these models, the line intensities depend on the velocity of the emitting cloud, as well as on the strength of the ionizing radiation. Thus, these models provide a starting point for the calculation of kinematic line profiles and for the explanation of the observed features. The emission-line profiles, and the integrated emission-line spectra, are calculated assuming that the narrow emission-line region (NLR) is composed of several clouds with different velocities determined by a distribution function. In a previous paper (Contini and Viegas-Aldrovandi 1987) the theoretical [OIII] line profiles were calculated and compared to the observed profiles. In this paper we summarize the results obtained for several emission-lines, taking into account the possibility of blending of close lines. A more detailed discussion will appear elsewhere (Contini and Viegas-Aldrovandi 1988).

The theoretical results are obtained assuming the emitting clouds are outflowing in a dilute gas ($n_0 \sim 300 cm^{-3}$) and are reached by the ionizing radiation from the central source on the edge opposite the shock front (ejection case). The cloud velocities are in the range 100 to 600 km/s, and follow an exponential distribution function characterized by r_{12}, the ratio between the number of clouds with velocity equal to 100 km/s and 200 km/s. For each cloud the theoretical line intensities are taken from Viegas-Aldrovandi and Contini (1988). Different types of integrated models have been built, depending on the relative importance of shock and photoionization in determining the physical conditions of the clouds. Basically, we have a shock-dominated model (SD – all clouds are shock-dominated), a radiation dominated model (RD – all clouds are radiation-dominated), and an intermediate case (SR – where low velocity clouds, $v_0 \leq 200$ km/s, are shock-dominated and high

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velocity clouds are mainly radiation-dominated). In each case, a synthetic emission-line spectrum is obtained in the range 1000 to 10000 Å, as well as the kinematic profile for the most representative emission-lines, using $r_{12} = 10$ and 100. The main results are the following:

a) For SD and SR models, the line ratios of the synthetic spectra depend on the value of r_{12}. For RD models, because the physical conditions in the clouds are mainly determined by photoionization, the synthetic spectra obtained with different values of r_{12} tend to be similar.

b) The synthetic spectra obtained can reproduce the different observed emission-line spectra depending on the relative importance of shock and photoionization.

c) As for the high excitation Fe lines, it seems that the UV line OVI 1031 could be the signature of shocks in the NLR. This line is intense in SD and SR models.

d)SD and SR models with $r_{12} = 10$ give broader lines with more complex profiles. In this case, blending between close lines may sometimes mimic line asymmetries.

e) Comparison of Hβ and [OIII] theoretical profiles with observations in different locations of NGC 1068 (Baldwin, Wilson and Whittle 1987) seems to indicate that a more flat distribution of cloud velocities ($r_{12} = 10$) should characterize the internal zone of the NLR, whereas the velocity distribution function should be steeper ($r_{12} = 100$) in the outskirts of the NLR, indicating a dominance of low velocity clouds in this zone.

f) The coefficient of variation (Whittle 1985b) obtained from the theoretical profiles are of the order of 0.22 for SD and SR models with $r_{12} = 10$. If $r_{12} = 100$, the theoretical coefficient is in the range 0.07 to 0.20. For RD models the line profiles are symmetric.

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