COMPOSITE MODELS: A TOOL FOR INTERPRETING THE EMISSION-LINE SPECTRA OF ACTIVE GALACTIC NUCLEI

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In the last decade, emission-lines from a large number of active galactic nuclei (AGN) have been observed. Most of the models built to explain the observed narrow emission-lines are based on photoionization. Although these photoionization models account for the observed general features, many points remain unexplained and several authors suggest an additional energy source (Ferland and Mushotzky 1984, Ferland and Osterbrock 1986, Stasinska 1984, Viegas-Aldrovandi and Gruenwald 1988). Another possible explanation is suggested by the emitting cloud motions, which account for the observed line widths. If the clouds are moving throughout a dilute gas ($n_0 \simeq 300$ cm^{-3}), a shock can develop. Then, the physical conditions in the cloud are determined by the coupled effect of photoionization and shock hydrodynamics.

To build models for the narrow emission-line region (NLR) we developed a computer code (SUMA) accounting for the presence of shock and photoionization (Contini and Aldrovandi 1986, and references therein). We assume plane-parallel symmetry for a cloud moving radially. Two cases are considered: (a) ejection – cloud moving outwards, and (b) infalling – cloud moving towards the center. The input parameters are: the preshock density, the shock velocity, the ionizing radiation spectrum, and the chemical composition of the gas. Presently, the code includes the following elements H, He, C, N, O, Ne, Mg, Si, S, Cl, A and Fe.

In the following we summarize the results obtained with the composite models and describe their success in explaining the observed features of the NLR of AGN. More detailed results and discussion will be published elsewhere (Viegas-Aldrovandi and Contini 1988a,b).

a) In the composite models the line emissivities are related to the cloud velocity, directly if the cloud is shock-dominated (SD), or indirectly (through the density distribution) if it is radiation-dominated (RD).

b) In the ejection case, the shock front and the ionizing radiation from the central source act on opposite edges of the cloud. The two ionized zones are separated by a neutral region if the geometrical thickness of the cloud is $d \geq 10$ pc.

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c) The best fit to observations is obtained in the case of ejection.

d) The low observed values of [OIII]5007/4363, and the high observed values of [OI]/Hβ and [NI]/Hβ are easily explained by the composite models.

e) Emission-line intensities are not smooth functions of the shock velocity and of the strength of the ionizing flux.

f) For clouds with velocity greater than 300 km/s, the Hβ luminosity produced by the shock effect is comparable to that due to photoionization, even for an ionization parameter greater than 10^{-4}.

g)The high excitation Fe lines, not explained by photoionization, can be reproduced by the composite models. They are produced in the post shock high temperature zone, mainly in clouds with velocity greater than 300 km/s. This predicts that more ionized species should show broader lines, as observed.

h) Seyfert 2, intermediate Seyfert galaxies and Liners are interpreted as different aspects of the same phenomenon, depending only on the relative importance of shock and photoionization in determining the physical conditions of the gas.

i) Seyfert 2 galaxies show low x-ray luminosity. The post shock high temperature zone produced in the composite models can be the source of the observed soft x-rays.

j) Finally, if the results obtained for the NLR can be extrapolated to denser clouds with higher velocities, several observed features of the BLR could also be explained by the composite models. In particular, the high x-ray luminosity of Seyfert 1 galaxies and QSOs, and the intense FeII lines generally observed in radio quiet objects can be understood in this manner.

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