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ON THE EFFECT OF RELATIVISTIC ELECTRONS IN THE NARROW LINE REGIONS OF ACTIVE GALACTIC NUCLEI

S.M.V. Aldrovandi, M.L. Cēsar and R.B. Gruenwald

Instituto Astronōmico e Geofīsico, USP
Brasil

ABSTRACT. The effect of relativistic electrons on a photoionized emission-line region is investigated, considering optically thick models. The main effect of these electrons is to heat the gas while their influence on the ionization structure is not very important. The calculated emission-line fluxes are compared to the available observational data.

Key words: active galactic nuclei; narrow line region; relativistic electrons

I. INTRODUCTION

Observational data concerning [OIII] lines indicate a temperature difference between Seyfert 2 (S2) and narrow line radiogalaxies (NRLG). In general, the temperature in the NRLG are greater than in the S2 nuclei (Cohen, Osterbrock, 1981). Photoionization is generally considered as the main mechanism assuring ionization and heating of the emission-line region of the galactic nuclei. However, an additional heating source seems to be necessary to explain the observed temperature difference. If the radio emitting nuclei are really hotter, this additional energy source can be relativistic electrons, which have lost part of its energy by synchroton effect.

A first analysis has been made by considering an incident flux of relativistic electrons on an optically thin photoionized gas (Cēsar et al., 1984). This simplified model shown that a relativistic electron flux is an important heating mechanism of the gas and can change the theoretical intensity ratio of the emission lines. These results justify a more refined model, taking into account the energy transfer.

In this paper some preliminary results for an optically thick gas are presented.

II. THEORETICAL MODEL

The photoionization model is based on Aldrovandi and Stasinska (1978) and Pēquignot et al. (1978) with the following updatings: the charge transfer coefficients are taken from Butler and Dalgarno (1980) and Butler et al. (1980); the dielectronic recombination rate at low temperatures comes from Nussbaumer and Storey (1983); the atomic data concerning the line emissivities come from the references cited by Mendoza (1983).

For the ionizing radiation a power law spectrum is assumed. The spectral index of the ultraviolet photons, α_{UV}, can be different from that of the X-rays, α_X. This radiation is also characterized by the ionizing parameter U (see Aldrovandi, in this volume).

Concerning the relativistic electrons, a monoenergetic flux is considered. The electrons reach the gas cloud with an energy of 10 MeV (Aldrovandi, Pēquignot, 1972). The results are quite independent of this initial energy, as long as the electrons are relativistic. The considered processes and data are given by Cēsar et al. (1984). In this paper it is taken into account the energy variation of the electrons due to excitation and ionization of the gas. From radio variability of radiogalaxies, the monoenergetic flux can be estimated and its value is in the range $\sim 10^6$ to $\sim 5 \times 10^8$ cm^{-2} s^{-1}.

III. RESULTS

The importance of an incident flux of relativistic electrons, Φ, on a optically thick cloud is exemplified by the following figures. All of them correspond to models with hydrogen density $n_H = 10^4$ cm^{-3} and spectral indexes $\alpha_{UV} = 1.5$ and $\alpha_X = 0.7$.

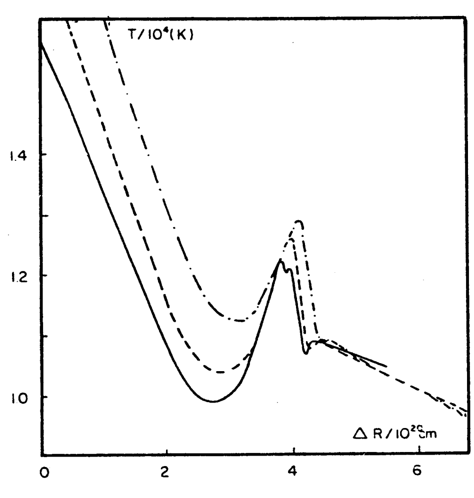

Figure 1 - Variation of the electron temperature as a function of the distance from the illuminated edge.

In Figure 1, the variation of the electron temperature through the gas cloud is given as a function of the distance from the illuminated edge. The corresponding ionizing parameter is $U = 3 \times 10^8$ cm s^{-1}. Solid, dashed and dashed-dotted curves correspond respectively, to $\phi/n_H = 0$, 10^5 and 3×10^5 cm s^{-1}. These curves show that relativistic electrons are an important heating mechanism throughout the cloud, i.e., for $\Delta R \leq 4 \times 10^{20}$ cm. For the outer regions, where the ionization degree is less than 0.1, the main role of the electrons is to maintain the gas ionization.

The incident electron flux affects the emission-line intensities. This effect is shown by two diagnostic diagrams (Figures 2 and 3) including helium and oxygen lines, which are important to limit the physical parameters of the model. In these figures, [OIII] stands for [OIII]$\lambda\lambda$(5007+4959), [OII] for [OII]$\lambda\lambda$(3726+3729), HeII for HeIIλ4686 and HeI for HeIλ5876. The solid line corresponds to photoionization models, with $\phi/n_H = 0$, and varying U. Dashed-dotted, dashed and dotted curves correspond, respectively, to U = 3×10^6, 3×10^7, 3×10^8 cm s^{-1}, and are parametrized by the value of log (Φ/n_H). Observational data are indicated by circled numbers, which represent the groups of active galactic nuclei defined by Contini and Aldrovandi (1983).

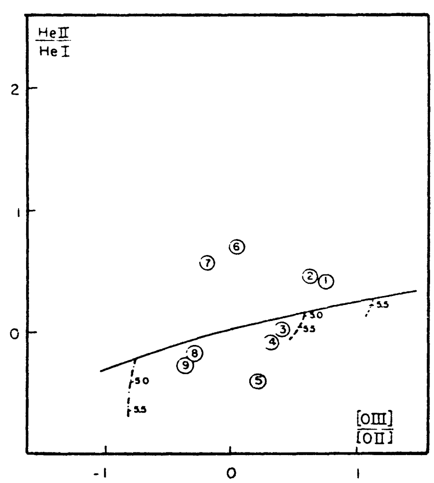

Figure 2 - HeII/HeI intensity ratio versus [OIII] / [OII] intensity ratio.

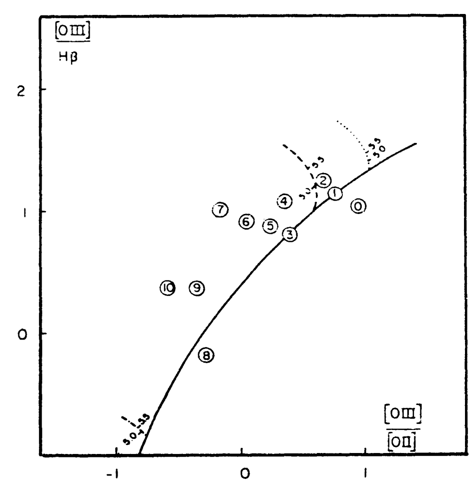

Figure 3 - [OIII]/H_β, intensity ratio versus [OIII]/[OII] intensity ratio.

In order to stablish the real importance of constructing composite models including relativistic electrons, other diagnostic diagrams must be analysed. Furthermore, recent photoionization models seem to indicate that a black body spectrum, for the ultraviolet radiation, is more adequate to fit observational data of various objects (Stasinska, 1984). These facts require further calculations, which are now in progress.

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S.M.V. Aldrovandi, M.L. Cēsar and R.B. Gruenwald: Instituto Astronômico e Geofísico, Universidade de São Paulo, Caixa Postal 30627, CEP 01051, São Paulo, SP, Brasil.