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LOW IONIZATION EMISSION LINES IN QUASARS

D. Dultzin-Hacyan

Instituto de Astronomía
Universidad Nacional Autónoma de México

RESUMEN. La posibilidad de que coexistan distintas regiones de emisión de líneas anchas en cuasares (y Sy 1) se ha considerado recientemente en la literatura. Se piensa en regiones fotoionizadas por el contínuo UV con distintas opacidades y estados de ionización (regiones dominadas por HII ó HI*). En este trabajo analizamos evidencia observacional (en particular de las líneas de MgII y SiII en cuasares) en favor de la coexistencia de estas nubes y también de nubes calentadas mecánicamente (emisión de líneas por ionización colisional).

ABSTRACT. The possibility of the coexistence of different kinds of BLR clouds in quasars (and Sy 1's) has been discussed recently in the literature. These clouds, photoionized by the UV central continuum would have different opacities and ionization states (HII or HI* dominated clouds). In this work we analyze observational evidence (in particular, MgII and SiII lines in quasars) in favor of the coexistence of these clouds as well as mechanically heated clouds (where lines are emitted following collisional ionization).

Key words: QUASARS

I. INTRODUCTION

Since their discovery, the emitting regions in quasars (and other active nuclei) were thought to derive their energy from the UV non-thermal continuum of the central source. It is commonly accepted that in these photoionized regions, collisional excitation is an important mechanism for the production of several lines (particularly low ionization lines, such as Balmer, FeII, SiII, MgII, CaII and so on).

There is an important discussion on the possibility of having another source of energy for the emission line region. This source would produce mechanical heating (by means of viscous dissipation, shocks, etc.) and hence collisional ionization.

Observations (e.g. Gaskell, 1984; Wilkes, 1984) as well as theoretical considerations (e.g. Collin-Souffrin et al., 1986) indicate that the broad line emission region (BLR) consists of, at least, two types of clouds (or filaments): those dominated by an HII zone with a small HI* transition zone (HI* is an excited HI region with $H^+/H^\circ \sim 10^{-1}$ and $T \sim 8000°K$), and those dominated by the HI* zone.

A third type of cloud, non radiatively, but mechanically ionized can also exist (Collin-Souffrin, 1986).

In what follows we present observational evidence in favor of the existence of the three types of BLR clouds, from observations of MgII and SiII in quasars, we include considerations of FeII emission from the literature.

II. SiII

Phillips (1978) first noted the absence of optical SiII lines in quasar's and Seyfert 1 spectra. This poses a problem within the frame of photoionization and fluorescence models. Collin-Souffrin et al. (1980) suggested the collisional ionization of these lines.

UV lines of SiII have been observed with the IUE satellite for a few active nuclei. In particular, the ratio SiII$\lambda\lambda$1196/1263 has been measured for two quasars: 3C 273 (Ulrich et al. 1979) and PKS 2251+113 (Dultzin-Hacyan, 1983). In both cases a ratio of $\sim$2 was found.

Dumont and Mathez (1981) have calculated the transfer of SiII lines for quasar's conditions. Using photoionized models by Netzer (1980) and Kwan and Krolik (1979) they predict a value <1 for the above ratio. The observed value for quasars (SiII$\lambda\lambda$1196/1163=2) is compatible only with collisionaly ionized models (for example Te=10,000°K and Ne=10^{10} cm^{-3} give a value of $\sim$2.5).

III. MgII

A line redward of MgIIλ2798 is particularly intense in the spectrum of Ton 469 (3C 232) (Grandi and Phillips 1978; Dultzin-Hacyan, 1985) this line has been identified as MgIIλ2934 by Grandi and Phillips (1978). Absolute fluxes for these lines were first obtained by Dultzin-Hacyan (1985).

Grandi and Phillips (1978) suggested two possible mechanisms for the emission of the MgIIλ2934 line: Lyβ and N V fluorescence. The first mechanism (Lyβ fluorescence) has been discarded (Dultzin-Hacyan, 1985) on the basis of examination of the UV spectrum of TON 469 (Dultzin-Hacyan, Salas, Daltabuit, 1981) where several lines predicted by this mechanism are absent. There is no contradiction with N V fluorescence. However, the collisional excitation of this line should be studied under high density (Ne $\sim$ 10^{10-11} cm^{-3}) conditions.

It is commonly accepted that MgIIλ2798 is collisionally excited even in the presence of a strong UV continuum. Collin-Souffrin et al. (1980) have shown that a collisional model predicts the observed values for I(MgIIλ2798)/I(FeIIλ4570) if $10^{10} \lesssim n_e \lesssim 10^{11}$ cm^{-3}.

IV. FeII

The discussion on FeII emission in active nuclei is very extensive in the literature (e.g. Collin-Souffrin et al., 1982; 1986; Joly, 1984; Wills, Netzer, Wills, 1985 and references therein). It is probable that most of the FeIIUV lines are emitted by fluorescence in an HI* region (Joly, 1981, Netzer and Wills, 1983, Collin-Souffrin and Dumont, 1986) and there is much discussion on the role of reddening to explain the observed FeIIUV/FeIIopt ratio (Wills, Netzer and Wills, 1985; Collin-Souffrin, 1986).

FeII opt emission is not correlated with FeIIUV emission (nor MgII emission), e.g. Bergeron and Kundt, 1984.

And a most important fact is that the observed values of FeII opt/Lyα and FeIIopt/Hβ cannot be explained by any combination of a photoionized model + reddening (Collin-Souffrin, 1986).

V. CONCLUSIONS

1. MgII and FeIIUV lines are emitted in HI* dominated regions of high density photoionized clouds. A contribution of optically thin clouds could also be important.

2. SiII and FeIIopt lines can be emitted by collisionally ionized clouds which are mechanically heated.

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Deborah Dultzin-Hacyan: Instituto de Astronomía, UNAM, Apartado Postal 70-264, 04510 México, D.F., México.