PHOTOIONIZATION MODELS AND LOW IONIZATION LINES IN AGN

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ABSTRACT. A two-component photoionization model where the high and the low ionization lines are allowed to arise from different kinds of clouds is explored. A spectral distribution of the incident radiation which tends to overestimate the X-ray flux around 3 keV is adopted in order to enhance the extent and heating of the excited HI region. It is concluded that the model is still unable to explain the observed ratio FeII/Hβ.

1. INTRODUCTION

Up to now one-component models of the broad line region of quasars fail to explain the strength of low ionization lines. In particular, FeII lines are too weak compared to Hα, Hβ and Lα in the photoionization models computed by Kwan and Krolik (1981), Kwan (1984), Wills et al. (1985). However, Collin-Souffrin et al. (1985) have ultimately tried to find if, under very favourable conditions it is possible to account for the low ionization lines in the framework of photoionization models.

It is allowed that the low and high ionization lines are emitted in two different kinds of photoionized clouds :

- the clouds emitting the high ionization lines are those usually described by standard models.
- the clouds responsible for the low ionization lines should have a larger excited HI zone (HI^*) produced by an intense X radiation (compared to the UV one), a high density and possibly an overabundance of heavy elements.

The code, mainly designed to study optically thick cases (up to $N_H \sim 10^{25}$ cm^{-2}) is described in Collin-Souffrin and Dumont (1985).

2. RESULTS

Table I summarizes the inputs and the main outputs of each run : n_o and T_o are the density and the temperature of the illuminated boundary, U is the ionization parameter, $Z/Z_\odot$ is the abundance of heavy elements,

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TABLE I : Characteristics of the models

Model	0	1	2	3	4	5
			Input data			
n_0 (cm^{-3})	3.6 10^9	3.6 10^9	3.6 10^9	3.6 10^{10}	3.6 10^{10}	3.6 10^{10}
U	.03	.003	.03	.003	.03	.03
Z/Z_0	1	1	1	1	1	3
H (cm)	6.1 10^{12}	1.57 10^{14}	1.53 10^{14}	5.3 10^{12}	5.4 10^{12}	5.4 10^{12}
			Out put data			
T_0 (°K)	22400	17150	22500	17500	24400	24000
P (bars)	2.2 10^{-2}	1.7 10^{-2}	2.2 10^{-2}	1.7 10^{-1}	2.4 10^{-1}	2.4 10^{-1}
<T> HI*	7700	5650	6500	6500	7400	6900
$<n_H>$ HI*	2.10^{10}	2.10^{10}	2.4 10^{10}	1.9 10^{11}	2.3 10^{11}	2.5 10^{11}
$<n_e>$ HI*	4.10^9	3.5 10^8	1.5 10^9	6.10^9	3.5 10^{10}	2.5 10^{10}
τ_L	4.6 10^5	2.5 10^7	2.6 10^7	7.2 10^6	6.0 10^6	8.3 10^6
τ_{Bac}	1.2	1.7	5.5	1.6	5.9	4.6
τ_{Pas}	.05	.01	.26	.08	.83	.64
τ_{2343}	5.3 10^4	2.3 10^6	2.5 10^6	1.9 10^6	6.6 10^5	2.5 10^6

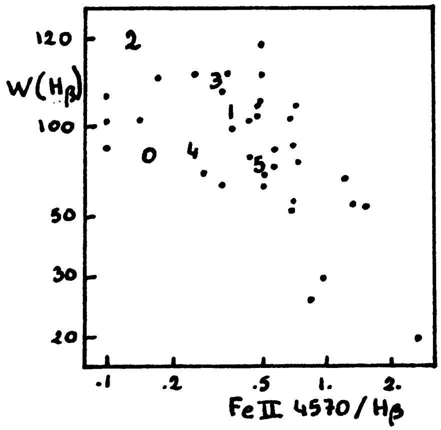

Figure 1

Figure 1 : W(Hβ) in Å versus FeII 4570/Hβ observed in 34 AGN plus the relevant theoretical values obtained with models 0 to 5 assuming a covering factor of the BLR Ω/4π = 0.1.

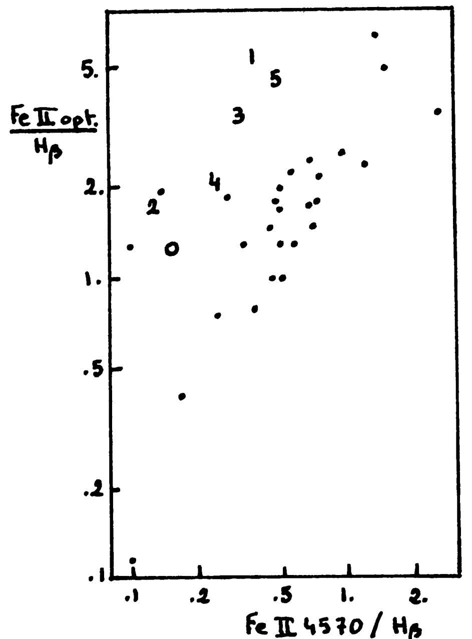

Figure 2

Figure 2 : FeII opt (λ ∿ 3000-6000)/Hβ versus FeII 4570/Hβ observed in 27 AGN. Numbers are as in Figure 1.

H is the thickness of the clouds in cm, P is the pressure, <T>, $<n_H>$ and $<n_e>$ are the average values of the temperature, atomic hydrogen density and electron density in the HI*, τ_L, τ_{Bac},τ_{Pas} the optical thickness at the Lyman, Balmer and Paschen limits and τ_{2343} is the optical thickness at the centre of FeII UV3.

Line ratios published for about 30 well observed AGN are gathered on

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Figure 1 and 2 together with the corresponding ratios obtained from our models.

Figure 1 shows an anticorrelation between W(Hβ) and FeII 4570/Hβ. Following Gaskell (1985) a constant coverage factor $\Omega/4\pi = 0.1$ is assumed. Models neither encompass the whole range of W(Hβ) and FeII 4570/Hβ nor explain the anticorrelation, in particular the coexistence of large FeII 4570/Hβ and small W(Hβ). The high density - high column density overabundant model yields FeII 4570/Hβ = 0.5, far below the ratio observed in I Zw1 (∿1.5), Mk 231 (∿1.4), 3C 232 (∿2.7) or PHL 1092 (∿6). Another interpretation of the correlation would be that in objects having a low coverage factor, there is a non photoionized region which could emit a lot of FeII and almost no Hβ (see for example Clavel et al. 1983).

Figure 2 shows the correlation between FeII opt/Hβ and FeII 4570/Hβ (FeII opt is the sum of all optical multiplets) a straightforward implication of the similar variations of all the optical FeII lines with physical parameters once the optical thickness is large (Joly 1981). The theoretical prediction for FeII opt(λ > 3000 Å)/ FeII 4570 is 4 times larger than the observed ratio, showing that both the near UV lines (∿ 3000-4000 Å) and, generally weak lines escape detection.

3. CONCLUSION

Two component photoionization models cannot account for the observed intensity of FeII. The average temperature in the HI* zone is always lower than 8000 K and the ratio FeII 4570/Hβ never exceeds 0.5. One needs to consider another kind of clouds to account for high FeII intensities. Furthermore, the ratio FeIIopt/FeII 4570 is always underestimated by observations. FeIIopt/Hβ which is observed to be ∿ 5-10, should be in reality 20-50.

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"Unfortunately no clear conclusion is yet reached since every model is able, according to the choice of some arbitrary parameters, to give results in agreement with the observations .... "

- Suzy Collin-Souffrin (p.303)