CAII - FeII CORRELATION IN ACTIVE GALACTIC NUCLEI

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1. INTRODUCTION

The presence of CaII emission in the red spectra of AGN is now commonly observed. A sample of forty AGN has been surveyed by Persson (1988): fourteen of his objects show a clear emission of the CaII triplet at 8498, 8542, 8662A (CaIIT) with a strength correlated with that of the optical FeII emission. The study of the CaII triplet puts new constraints to the physical conditions in the low ionisation region of the BLR.

Joly (1988) has determined the physical conditions required to explain the observed intensities by computing the CaII emission produced by an homogeneous cloud in collisional equilibrium. The emission region has a constant density and electron temperature, it is shielded from the UV ionizing photons. Furthermore, the CaII emission has been computed in one photoionisation model i.e. in presence of an incident continuum flux extending up to 200keV, with a low ionisation parameter. Model 2a of Collin-Souffrin, Hameury and Joly (1988) which, up to now, is the photoionisation model providing the best fit to optical FeII observations, has been used. The CaII intensities are compared to the FeII ones obtained for the same models by Joly (1987) and Collin-Souffrin, Hameury and Joly (1988) and to the observations published by Persson (1988).

The computations have been performed with the code described in Collin-Souffrin and Dumont (1986). The Ca^+ atom is approximated by a 5-level atom plus a continuum. There is a coïncidence between the energy of Lα and the ionisation potential from the metastable level of Ca^+ (10.17eV). This level is very populated and the ionising process is very efficient. Solar abundances of calcium and iron are used.

2. RESULTS

The results of the computations are plotted in Figure 1 together with intensity ratios observed by Persson (1988) in 14 AGN. CaIIT/Hβ is plotted versus FeII/Hβ. CaIIT is the sum of the three lines of the CaII triplet and FeII is the blend at 5190A, 5320A (multiplets 48,49 and 41).

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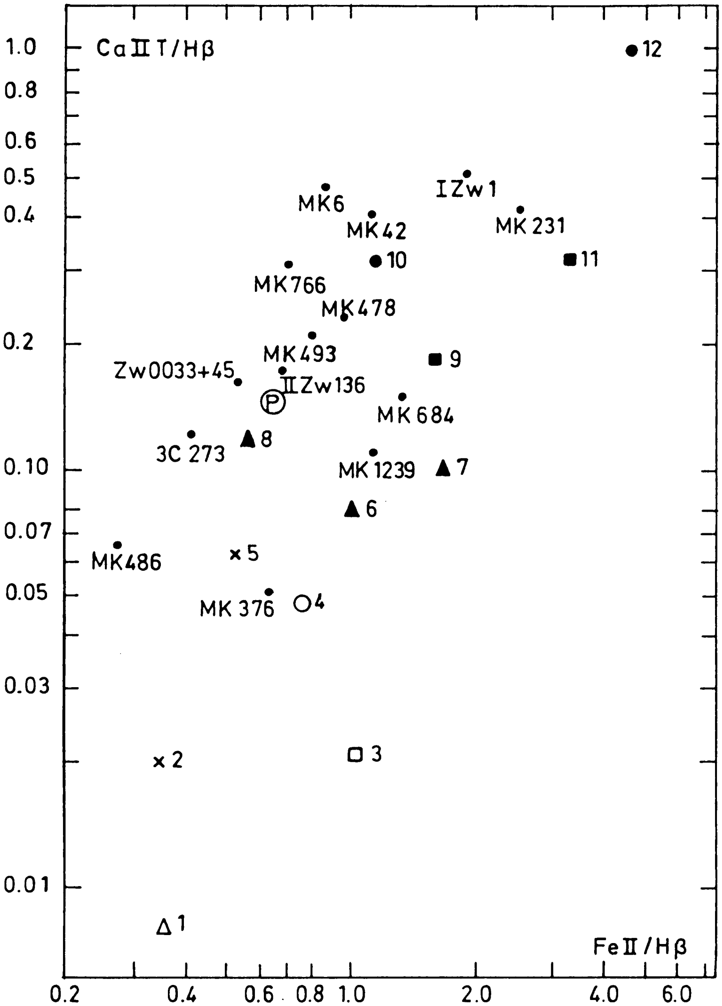

Figure 1. CaIIT/Hβ versus FeII/Hβ. CaIIT is the sum of the 3 lines of the IR triplet FeII is the blend at 5190A, 5320A, sum of multiplets 48, 49, 41. The observed values are from Persson (1988). The computed values are located by symbols according to the temperature and density of the models: open symbols are for $n=10^{11}cm^{-3}$, full black symbols for $n=10^{12}cm^{-3}$ and: O =6000K, □ =6500K, Δ=7000K, X=8000K. Ⓟ is for the photoionisation model.

The correlation between CaII and FeII is obvious. It derives from the similar behaviour of these lines with the physical conditions, due to the similar configuration of the Ca^{+} and Fe^{+} atoms.

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A consequence of the photoionisation of Ca^+ by $L\alpha$ photons is weak optical thickness and weak intensity ratios relative to Hβ for all the CaII lines due to the low abundance of Ca^+ atoms. The CaII/ Hβ intensity ratios increase noticeably with density and decrease with temperature while they decrease with column density at low temperature and increase with column density at high temperature. Similar behaviours are observed with FeII (Joly 1987) because of the relative variations of Hβ with physical conditions.

The CaIIH+K/CaIIT ratio increases with temperature and decreases with column density while it does not vary with density. These variations can be compared to the behaviour of the ratio FeIIUV/FeIIopt at very low optical thickness. When the temperature decreases or the geometrical thickness and therefore the optical thickness increase, the CaII H and K and the FeIIUV photons are converted into CaIIT and FeIIopt photons respectively, owing to the common upper levels of the resonance and subordinate lines and to the lower optical thickness of the subordinate lines.

Note the great similarity between the photoionisation model and the collisional ones with low temperature. It derives from the low ionisation parameter and the high density of the model.

There is a very good agreement between models and observations. Temperature ranges between 6000 and 8000K for a density $n=10^{12}cm^{-3}$ and is restricted to 6000K for a density $n=10^{11}cm^{-3}$. Column density ranges from 10^{23} to $10^{25}cm^{-2}$; the lower the temperature and the weaker the density, the larger the column density. However, the low density model ($n=10^{11}cm^{-3}$, T=6000K, $N=10^{25}cm^{-2}$; Model 4) accounts only for the weakest CaII emitters . The strongest CaII emitters which are also the strongest FeII emitters require low temperature (6000-6500K) and high density ($10^{12}cm^{-3}$).

No observation of CaIIH+K in emission in AGN is reported in the literature. However a feature at 3967A is sometime identified as [NeIII]λ3967 plus Hελ3970 (Phillips, 1978; Osterbrock and Pogge, 1985). From the values quoted by Phillips (1978) and Osterbrock and Pogge (1985) for this feature and assuming that CaII H is contributing to it by no more than 50%, we can infer that CaIIH/Hβ should be less than 0.05 unless some absorption balances the emission. Either the temperature is weak and the column density high in order to minimize the ratio CaIIH+K/CaIIT without changing CaIIT/Hβ (Joly 1988), or some AGN (IZw1, Mk6, Mk42, Mk231, Mk766) have CaII H and K in emission partly hidden by absorption components. It should be worthwile to have a new insight on AGN spectra in this wavelength range and we should likely discover blends of CaII emission-absorption.

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