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Inconsistency of Photoionization Models for NGC 5548: Proof of Mechanical Heating?

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Abstract. It is shown that, in the case of NGC 5548, photoionization models cannot account for line fluxes, line ratios, and line variations. The assumption that a fraction of the broad-line region is mechanically heated can solve the problem.

The observations upon which the study is based are those corresponding to the first period of the AGN Watch series for the line fluxes (Clavel et al. 1991, Peterson et al. 1991, Dietrich et al. 1993), and the overall spectral distribution is obtained from a compilation of *EUVE*, *ROSAT*, *GINGA*, and *CGRO* OSSE observations. We use the time lags between lines and continuum fluxes as distance indicators, and we deduce the ionizing photon density $Un_{\rm H}$ where U is the usual ionization parameter. Models are computed with CLOUDY or with our own code. The column density is assumed infinite and the abundances are normal. We stress the existence of three problems.

1. An 'Energy Budget Problem'

Figure 1 illustrates the problem for Lyα, Hα, and Hβ. We find that none of the computed fluxes is compatible with the observed ones, unless the values of $Un_{\rm H}$ are at least one order of magnitude smaller than those given by the time lags. The problem is particularly accute for Hα whose computed flux is at least three times smaller than the observed value.

2. A 'Line Ratio Problem'

When one takes into account the time lags, it is impossible to account for the observed line ratios with a mixture of emission regions having different dimensions and physical properties. The problem lies mainly in the fact that the Hα/Hβ ratio is close to the observed ratio only for $Un_{\rm H} \approx 10^{7.5}\,{\rm cm}^{-3}$, a value totally incompatible with the time lag. One finds also that the He II λ1640/He II λ4686 ratio is much larger than the observed ratio for any value of $Un_{\rm H}$ and that only the computed C IV/Lyα ratio is marginally consistent with the observed value.

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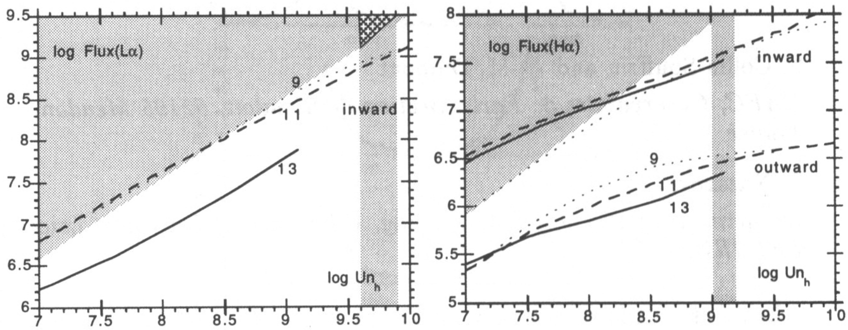

Figure 1. Logarithm of the flux versus logarithm of $Un_{\rm H}$. The regions allowed by the time lags (vertically limited) and by the observed values of the fluxes (limited by a diagonal) are drawn in grey. The limit diagonals correspond to a coverage factor equal to unity, and if it is smaller, the diagonal has to be shifted towards the top by the same amount. The curves are labelled with the density, and the flux coming from the illuminated side of the cloud (inward) and from the cold side (outward) are given separately.

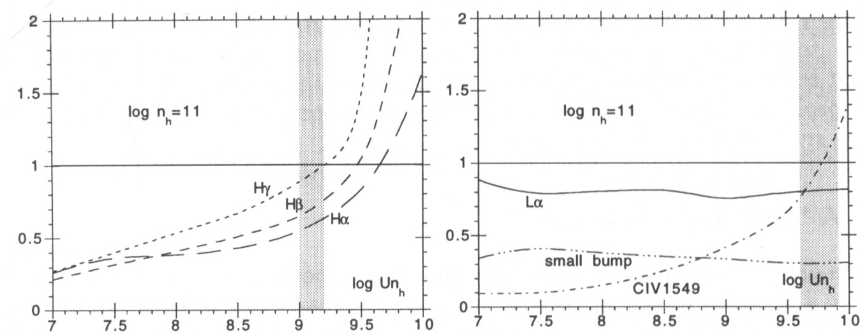

Figure 2. $\delta \log F_{\rm ionizing} / \delta \log F(1350\,\text{Å})$ as a function of $\log Un_{\rm H}$ for several lines. The regions allowed by the time lags are shown in grey.

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3. A Problem of 'The Slopes of the Variations'

This problem is illustrated in Fig. 2. It shows

1. Lines emitted by the same regions and drawing their energy from the same part of the ionizing continuum, such as the Balmer lines, do not have the same value of $\delta \log(F_{\rm ionizing})/\delta \log F(1350\,\text{Å})$.

2. This parameter is smaller than unity for all lines except C IV, contrary to what is inferred from EUV and UV correlated observations, which show that the flux variability increases from the optical to UV and to EUV (Marshall et al. 1996).

We discuss several possibilities for reducing these inconsistencies (influence of the column density, of the abundances, of the reddening, anisotropic emission, special geometries, etc.), and we conclude that the problems can be solved if one assumes that a non-radiative mechanism provides the energy of a part of the BLR, particularly of the Balmer (and Fe II) line-emitting region.

References

Clavel, J., et al. 1991, ApJ, 366, 64.
Dietrich, M., et al. 1993, ApJ, 408, 416.
Marshall, H. L., et al. 1996, preprint.
Peterson, B. M., et al. 1991, ApJ, 368, 119.