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The Nature and Origin of Structure in Broad Emission Line Profiles

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Abstract. We postulate that all structure in broad lines can be explained by a central component (at the systemic redshift) and the addition of two 'displaced components', one blueshifted and the other redshifted. We have been able to successfully classify all Balmer-line profiles on this basis. 3C 390.3-type objects are merely examples where the shifts of the displaced components are unusually large. We believe that the displaced peaks are less prominent in the UV lines because the higher ionization lines are broader.

1. Introduction

There is a class of quasars with 'displaced' broad emission-line peaks at velocities substantially different from the systemic velocity given by the NLR (Gaskell 1983). We will refer to these as '3C 390.3 objects' after the prototypical object (Sandage 1966). Gaskell (1983) proposed that the displaced peaks were due to orbiting supermassive black holes, each with an associated broad-line region. This theory and others offered to explain the peaks (jets, disks, etc.) are reviewed in detail in Gaskell (1996a) along with observational details.

The main thesis of this paper is that structure in broad-line profiles in *all* quasars can be explained by a central component and the addition of two displaced peaks (whatever their origin might be). The 3C 390.3 objects are simply quasars where the displaced peaks are very obvious. To investigate this we have modeled the displaced peaks as two Gaussians.

2. Results

Fitting 3C 390.3 objects using two displaced Gaussians is not difficult. Figure 1a shows a typical match to 3C 390.3 itself. The blue peak has been discovered to vary substantially in relative velocity (Gaskell 1996b). Figure 1b shows the same simulation but with the velocities halved. The change in appearance is striking. Notice how subtle the effects of the displaced components are now, even in noise-free simulated spectra. If a displaced component is weak, or shifted by only a small velocity compared with the line width, it can be completely lost. There are many quasars showing the sort of subtle profile asymmetries of Fig. 1b.

In the light of simulations such as those shown in Fig. 1b, we have been able to successfully classify all high-quality profiles and explain all profile variability.

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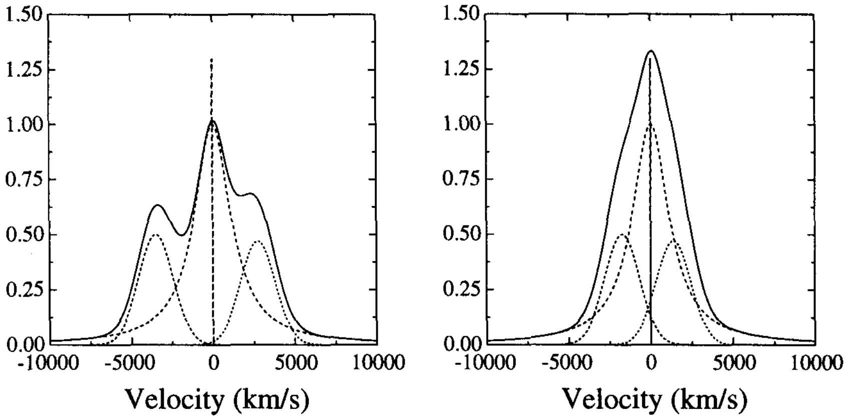

Figure 1. (a) A simple model of the Balmer lines in 3C 390.3 matching the appearance in 1981 or 1988. (b) The same line widths and line ratios as in (a), but with half the velocity displacements.

In the binary black-hole model, the more subtle cases are predicted to be the most common, as is observed.

The best examples of the 3C 390.3 phenomenon are seen in the Balmer-line profiles. Is it absent in the UV lines, indicating perhaps that the Balmer lines have a very different origin from the UV lines? We believe that Fig. 1b offers the explanation. The high-ionization lines in quasars are significantly broader than the Balmer lines. If the lines in Fig. 1a are broadened by a factor of two the result will be a profile like that in Fig. 1b and again, the displaced peaks almost vanish. Structure in UV lines is going to be more subtle than in the Balmer lines. We are attempting to test this with *HST* data.

We conclude (1) that the phenomenon of displaced BLR peaks is probably present in *all* quasars, not just the extreme 3C 390.3 objects, and (2) that it is probably present in all broad lines.

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References

Gaskell, C.M. 1983, in Quasars & Gravitational Lenses, 24th Liège Astrophysical Colloquium, p. 473.

Gaskell, C.M. 1996a, in Jets from Stars and Active Galactic Nuclei, ed. W. Kundt (Springer: Berlin), p. 165.

Gaskell, C.M. 1996b, ApJ, 464, L107.

Sandage, A.R. 1966, ApJ, 334, 95.