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DOUBLE- (AND SINGLE-) PEAKED EMISSION LINES AS PROBES OF THE STRUCTURE OF THE OUTER ACCRETION DISKS IN AGN

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Broad, double-peaked Balmer emission lines provide dynamical evidence for the presence of an accretion disk feeding a supermassive black hole in the central engines of AGN.

The double-peaked line profile is variable on timescales of months to years without any correlation to the variability of the continuum. This indicates that the profile variability traces structural changes in the accretion disk. Large-amplitude, long-time scale variations can be explained by global models such as a logarithmic spiral, but rapid, small-amplitude variations are also observed. We compute Hα line profile series by integrating a clumpy disk emissivity function over the surface of the accretion as the pattern rotates differentially, following the basic meethod described by Chen & Halpern (1989). From these line profiles, we measure the line parameters as a function of time and produce periodograms, which we compare to the corresponding observed periodograms of Arp 102B. We find that a stochastic emissivity pattern on the accretion disk can reproduce the observed short-term variability patterns. In 7% of the 1000 realizations of the clumpy disk model, the periodograms of line profile parameters resemble those observed in Arp 102B (see Figure 1).

We also recomputed the Murray & Chiang (1997) model for the radiative transfer effects in a disk wind to include relativistic effects. We then implemented this model so that it can be applied to any underlying emissivity function. We show the effect of an increase in disk-wind optical depth on a underlying logarithmic spiral arm emissivity function for a complete rotation of the arm (Figure 2). All the model parameters are the same except the optical depth which increases from 0.1 (left) to 10^7 (right). At low optical depth, the double-peaked line profile is variable at all wavelengths with inversion of the peak flux ratio and variability in the wings. At high optical depth, the line profile is single-peaked and the central core is the most variable part. (Note that the wavelength scale is different from the low optical depth case). So radiative transfer in a disk wind of high optical depth can transform a highly-variable, double-peaked emission line into a moderately-variable, single-peaked line. This indicates that our understanding of the accretion disk structure of double-peaked emitters can be generalized to the whole population of AGN even though double-peaked emission lines are found in only 20% of radio loud AGN and 4% of all AGN.

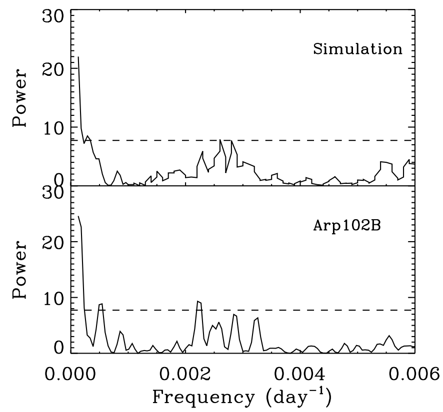

Fig. 1. Example of a simulated FWQM periodogram for the clumpy disk model, which resembles that of Arp102B. Any power peak above the dashed line is over 95% significant.

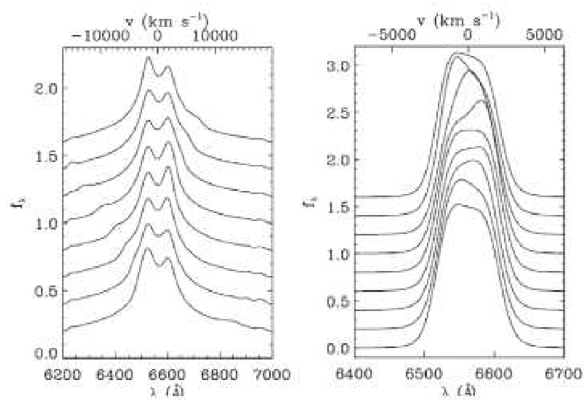

Fig. 2. Line profile series for a disk with a spiral arm seen through an accretion disk-wind of $\tau \sim 0.1$ (left) and $\tau \sim 10^7$ (right).

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