Deformation of P Cygni Line Profiles by Gravitational Microlensing Effects

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In addition to the well-known induced photometric effects, the gravitational magnification of a light source by stellar-mass lenses may also affect the spectral line profiles if the different parts of the profile originate from different emitting regions in the source plane and if the size of these regions is comparable to the characteristic lensing radius (Kayser et al. 1986). As noticed by Surdej (1990), this may be particularly important for the broad absorption line (BAL) quasars because the projected size of the BALR is similar to that of the continuum emitting region and therefore comparable to reasonable lensing radii. Good evidence for such microlensing effects on BAL line profiles is suggested by the spectroscopic observations of the multiple components of the BAL quasar H1413+117 (Angonin et al. 1990).

In this context, we have investigated here the effects of the chromatic magnification due to microlensing on the spectrum of BAL quasars assuming that they are constituted of a central continuum source surrounded by a rapidly expanding atmosphere, a model which may account for the observed P Cygni-type profiles at least in some cases.

In order to delineate the main characteristics of the spectral variations due to microlensing, we have adopted a model that is as simple as possible. The P Cygni-type profiles have been computed in the framework of the Sobolev approximation for a rapidly, spherically symmetric, expanding atmosphere which is accelerated outwards around a central core. Both resonance scattering and collisional excitation have been assumed to contribute to the line formation process.

The adopted lens was a single point-like star positioned at different projected distances from the central core in order to magnify different parts of the expanding envelope. The resulting P Cygni-type profiles were obtained by integrating over the source plane the spectral intensity of the radiation field emerging from the envelope along the line-of-sight and multiplied by the amplification pattern determined for a given projected distance and characteristic radius of the lens.

For reasonable values of the characteristic lensing radius and BELR size, say 10 and 100 radii of the continuum emitting core respectively, drastic changes of the profiles may occur. The deformations of the profiles essentially appear when the lens is approximately aligned with the source while the changes due to a decentered lens remain small.

The modifications of the P Cygni line profiles due to microlensing effects are mainly characterized by a net increase of the whole absorption component relative to the emission one. This increase of the absorption may be strong enough to transform a nearly pure emission line profile into a more typical P Cygni-type one.

For plausible values of the transverse velocities of the source, the observer and the lens, these profile variations may occur with a typical timescale of ten years. This order of magnitude is in quite good agreement with the timescale of line profile variations reported for some BAL quasars (see e.g. Turnshek et al. 1988; Smith et al. 1988).

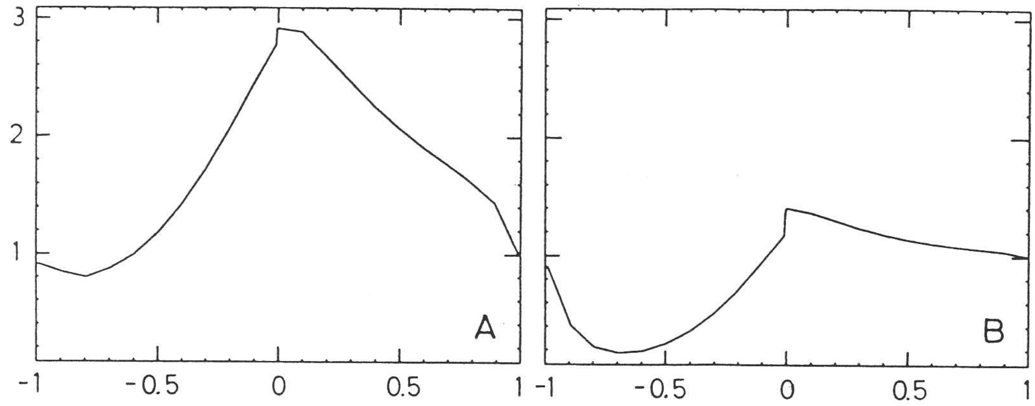

Fig. 1. An example of line profiles computed with (B) and without (A) microlensing effects. In this case, collisional excitation dominates the process of line formation. Abscissae are dimensionless frequencies and ordinates fluxes normalized to the continuum.

This research was supported in part by contract ARC 90/94-140 "Action de recherche concertée de la Communauté Française" (Belgium).

References

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