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COULD THE SHAPE OF Mrk 205 Fe Kα LINE BE EXPLANED BY MICROLENSING EFFECT?

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Abstract. We discuss the unusual shape of Mrk 205 Fe Kα line in the light of microlensing influence of a caustic from the galaxy NGC 4319. The shape of the Fe Kα line may be described as disc emitted line deformed by microlensing effect of a star with mass less than 0.2 $M_{\odot}$ from the NGC 4319 star disc. In the paper we discuss the two scenarious of line variation, if the microlensing effect is present.

1. Introduction

The objects Mrk 205 and NGC 4319 are interesting, because their nuclei are close each other. Mrk 205 is a low redshifted (z=0.071), low luminosity quasar ($M_V = -23$) located only about 0.7′ away from the center of the nearby spiral galaxy NGC 4319 (z=0.00468). In many papers the possibility of their physical connection was discussed (Burbridge 1996, Bubridge and Hoyle 1996, Arp 1998). On the other side, Baryshev & Ezova (1998) and Bukhmastova (2001) explained the appearance of quasar-galaxy pairs (as Mrk 205 - NGC 4319) by theorizing that distant AGNs experienced mesolensing by globular clusters in the halos of more nearby galaxies.

The quasar is viewed through the outer disc of the galaxy (Bahcall et al. 1992, Bowen & Blades 1993). The shape of UV and optical lines are typical for quasars and Sy 1 galaxies (Bahcall et al. 1992, Corbin & Boroson 1995), while it has an unusual weak UV bump (McDowell et al. 1989), indicating that the thermal disc emission is hidden in extreme UV. Recent observations with XMM-Newton have revealed a remarkable Fe K_{α} line profile (Reeves et al. 2001). The profile can be resolved into a narrow component located at 6.4 KeV and a broad component at 6.7 KeV which is inconsistent with the relativistic profile expected from the inner accretion disc (Fabian et al. 1989) assumed to be present in majority of Active Galactic Nuclei (AGNs) (Nandra et al. 1997). In the paper Reeves et al. (2001) it was suggested that the broad component at 6.7 KeV is 'most likely' originating from X-ray reflection off the surface of a highly ionised accretion disc.

Concerning the fact that the Mrk 205 is viewed through the outer disc of the NGC 4319, the microlensing effect of stars from the outer disc can influence on the emission line shape. Recently (Popović et al 2001ab, 2002ab) considered the influence of microlensing on the spectral line profile generated by a relativistic accretion disc in the Schwarzschild geometry, finding that significant changes in the line profile can be induced by microlensing. The scope of these studies has been the region where the broad X, UV and optical lines are generated. However, microlensing detection should be much more favourable in the tiny region generating the X-Ray radiation (Popović et al. 2001b, 2002ab). Thus it seems clear that the Fe Kα line can be strongly affected by microlensing and recent observations of two lens systems seem to support this idea (Oshima et al. 2001, Chartas et al. 2002).

In this paper we are going to discuss the unusual Mrk 205 Fe K_α line profile (Reeves et al. 2001) considering the possibility that such line profile is due to microlensing effects caused by a star from the foreground galaxy NGC 4319.

2. Results

Influence of the microlensing effect on a line generated by a relativistic accretion disc rotating around a Black Hole (BH) is analyzed in paper Popović et al. (2002a), where the ray tracing method (Bao et al. 1994, Bromley et al.1997, Fanton et al. 1997, Čadež et al. 1998) for line profile calculation were used.

2. 1. ESTIMATION OF THE CAUSTIC PARAMETERS

To model the unusual Mrk 205 Fe K_α line shape first we calculated the Einstein Ring Radius (ERR) expressed in gravitational radii (GM/c^2) for different masses of the lens which belongs to the NGC 4319 using the relation

$$\eta_0 = \sqrt{\frac{4GM_{ml}}{c^2} \cdot \frac{D_s D_{ds}}{D_d}}, \qquad (1)$$

where G is the gravitational constant, M_{ml} is the mass of the lens, and D_s, D_d and D_{ds} are the angular distances between observer – source, observer – deflector and deflector source, respectively. The distances can be calculated using the relation (Grogin & Narayan 1996)

$$D(z_i, z_j) = \frac{2c}{H_0} \frac{(1 - \Omega_0 - G_i G_j)(G_i - G_j)}{\Omega_0^2 (1 + z_i)(1 + z_j)^2} \qquad (2)$$

where H_0 is the Hubble constant and z_i, z_j are the redshifts, here we suppose that H_0=50, and Ω_0=1. The factors $G_{i,j}$ are

$$G_{i,j} = \sqrt{1 + \Omega_0 z_{i,j}} \qquad (3)$$

Finally, for the case of Mrk 205 and NGC 4319 we obtained the relation between the ERR (in gravitational radii) and mass of deflector (in Solar masses) as

$$\eta_0 = 6476\sqrt{M_{ml}}. \qquad (4)$$

The ERRs for three masses of deflector are given in Table 1. As one can see from the Table 1, very small objects (about 0.001 $M_\odot$) have enough ERR to cover a big part of X-ray accretion disc (order of hundred gravitational radii).

Table 1: The mass of lenses and corresponding ERR in gravitational radii for the case of Mrk 205 and NGC 4319

M_{ML} ($M_\odot$)	0.001	0.01	1
ERR (R_g)	204	647	6476

For further calculation we accepted the parameters of caustic (Popović et al. 2002a): $\beta = 1$, $A_0 = 1$ and we tested the line profile shape changing the position of the caustic as well as the ERR.

2. 2. MODELING OF MRK 205 FE K_α LINE

In order to compare the modeled profile with the observed one, we took observations from Reeves et al. (2001). First we subtracted the continuum as was proposed in Reeves et al. (see their Fig. 2), after that we compared our calculated profile with the observed one. We accepted that narrow line located at 6.4 KeV (rest frame) is arising from a neutral matter distant from the black hole (Reeves et al. 2001), and we modeled only the broad component with the peak at 6.7 keV.

First we started from the parameters of the emitting disc proposed by Reeves et al. (2001); $i = 45°$, $R_{out} = 1000\ R_g$ and emissivity of $p = -2.5$, but we found the best fit with following parameters: $i = 40°$, $R_{inn} = 10\ R_g$, $R_{out} = 500\ R_g$, p=-2.5. The location of caustic is at $X_c = -90$, $Y_c = 0$ and that ERR is about 2800 R_g that corresponds to a star with mass less than 0.2 Solar masses. In Figure 1. the comparison of the observed line profile with the calculated one is presented. As we can see from that figure, the model of an accretion disc plus microlensing effects of a star from NGC 4319, can describe the broad component of Mrk 205 Fe K_α line.

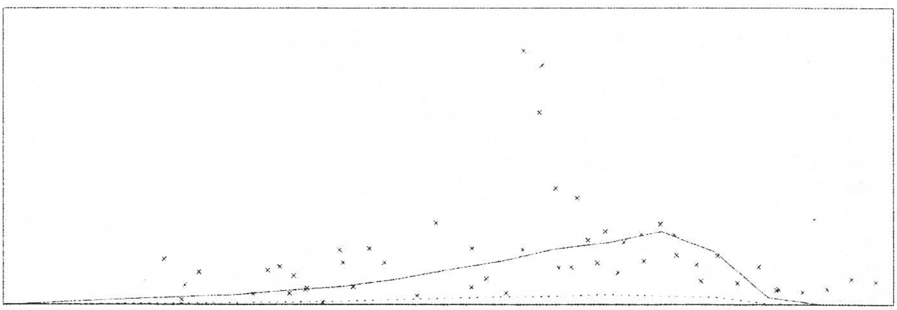

Fig. 1: The fit (solid line) of observed data (x-x-x) with the XMM-Newton (EPIC MOS and PN detectors) in comparison with the undisturbed disc line (dashed).

Moreover, we calculated the line profile in future if the MLE influence is present. The line profile would change in two ways, depending on the caustic motion direction. If caustic would cross from the approaching to the receding part of the disc the line would arise in intensity and peak of the line would move to the approaching side. After the caustic crosses the central part, the peak would move to the receding part and line would again become weaker. On the other side, if the movement of the caustic is from the receding to the approaching side, the line would change very slowly, and peak would move to the red part of the line, but not as dramatically as in the previous case.

3. Discussion and Conclusion

We considered the possibility that the unusual line profile of Mrk 205 Fe K_α line is caused by microlensing effect of a star from the NGC 4319 stellar ring, and we found:

1) That small objects (of the order of 0.001 $M_\odot$) from the NGC 4319 stellar ring can produce significant changes in Mrk 205 Fe K_α line profile.

2) That the unusual shape of Mrk 205 Fe K_α line can be modeled by emission of an accretion disc with parameters $i = 40°$, $R_{inn} = 10\ R_g$, $R_{out} = 500\ R_g$ p=-2.5 which emission is deformed by a caustic from the NGC 4319 stellar disc. We found that the location of the caustic is at $X_c = -90$, $Y_c = 0$ and that ERR is 2800 R_g corresponding to a star with the mass less than 0.2 Solar masses.

3) That if the unusual Fe K_α profile is due to MLE influence we can expect the two scenarios of the line variation depending on caustic motion direction. An extended discussion about this will be published elsewhere (Popović et al. 2002b)

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