Lecture 1

Observations of microimages and astrometric microlensing for distant quasars with the space based radio telescope RADIOASTRON

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Abstract

In this decade the space radio telescope RADIOASTRON will be launched. This project was initiated by Astro Space Center (ASC) of Lebedev Physical Institute of Russian Academy of Sciences (RAS) in collaboration with other institutions of RAS and RosAviaKosmos. The project was approved and now it is developed smoothly. This 10-meter radio telescope will be used for space ground VLBI measurements. The measurements will have extraordinary high angular resolutions, namely about 1 – 10 microarcseconds (in particular about 8 microarcseconds at the shortest wavelength 1.35 cm), therefore it will be a possibility to observe micro-images of distant quasars, since typical angular distances between microimages are about few microarcseconds for stellar mass microlenses. Therefore, such an instrument provide direct evidences for microlensing since variability of quasar image give only a necessary condition for microlensing, but not sufficient one. Moreover, RADIOASTRON could detect astrometric microlensing by objects in the Galactic Halo, by cosmological distributed microlenses and by microlenses in gravitational macro lenses. We evaluate probabilities to observe micro-images and astrometric microlensing for distant quasars for different kinds of microlens populations. The astrometric displacement of images could reach dozens of angular arcseconds for analyzed cases. We discuss some other applictions of RADIOASTRON facilities for gravitational lens investigations. Therefore, observations of distant images with the RADIOASTRON could give a very useful information about a cosmological mass density of microlenses which could contribute in baryonic dark matter concentrated in black holes, neutron stars and faint white dwarfes and in non-baryonic dark matter concentrated in stellar mass neutralino stars (clouds).

Lecture 2

Dark matter searches with an analysis of microlensing for distant quasars

Abstract

We consider a contribution of microlensing in X-ray variability of high-redshifted QSOs. Such an effect could be caused by stellar mass objects (SMO) located in a bulge or/and in a halo of this quasar as well as at cosmological distances between an observer and a quasar. Here, we not consider microlensing caused by deflectors in our Galaxy since it is well-known from recent MACHO, EROS and OGLE observations that the corresponding optical depth for the Galactic halo and the Galactic bulge is lower than 10^{-6}. Cosmologically distributed gravitational microlenses could be localized in galaxies (or even in bulge or halo of gravitational macrolenses) or could be distributed in a uniform way. We have analyzed both cases of such distributions. As a result of our analysis, we obtained that an optical depth for microlensing caused by stellar mass objects is usually small for quasar bulge and quasar halo gravitational microlens distributions ($\tau \sim 10^{-4}$). On the other hand, the optical depth for gravitational microlensing caused by cosmologically distributed deflectors could be significant and could reach $10^{-2} - 0.1$. It means that cosmologically distributed deflectors may significantlly contribute to the X-ray variability of high-redshifted QSOs ($z > 2$). Considering that upper limit of the optical depth ($\tau \sim 0.1$) corresponds to the case when dark matter forms cosmologically distributed deflectors, therefore observations of X-ray variations of unlensed QSOs can be used for the estimation of the dark matter fraction of microlenses.

Lecture 3

The iron K_α-line as a tool for analysis of black hole characteristics

Abstract

Recent X-ray observations of microquasars and Seyfert galaxies reveal broad emission lines in their spectra, which can arise in the innermost parts of accretion disks. Simulations indicate that at low inclination angle the line is measured by a distant observer as characteristic two-peak profile. However, at high inclination angles ($> 85^0$) two additional peaks arise. This phenomenon was discovered by Matt et al. (1993) using the Schwarzschild black hole metric to analyze such effect. They assumed that the effect is applicable to a Kerr metric far beyond the range of parameters that they exploited. We check and confirm their hypothesis about such a structure of the spectral line shape for the Kerr metric case. We use no astrophysical assumptions about the physical structure of the emission region except the assumption that the region should be narrow enough. Positions and heights of these extra peaks drastically depend on both the radial coordinate of the emitting region (annuli) and the inclination angle. It was found that these extra peaks arise due to gravitational lens effect in the strong gravitational field, namely they are formed by photons with some number of revolutions around black hole. This conclusion is based only on relativistic calculations without any assumption about physical parameters of the accretion disc like X-ray surface emissivity etc. We discuss how analysis of the iron spectral line shapes could give an information about an upper limit of magnetic field near black hole horizon.