Mon. Not. R. Astron. Soc. **000**, 000–000 (0000) Printed 19 November 2013 (MN LATEX style file v2.2)

Probing internal structure of distant quasars using Microlensing

19 November 2013

ABSTRACT
We present a toy model to parametrize and constraint the innermost environment of a distant quasar using microlensing.

Key words: Supermassive black holes, microlensing, quasars.

1 INTRODUCTION

The neighbourhood of the galactic centres are mysterious places. There is very little information available to accurately map the geometric structure close to the horizon of the supermassive black holes at the galactic centre. Observing these places with great spatial resolution is one obvious solution, however, requires high quality data. The future generation telescope, like mm-VLBI, EHT etc, are capable of resolving these structures. Nevertheless, there is an alternative solution for this problem, indirect mapping of the geometry.

Microlensing provides us with an opportunity to detect the signals, comprehensively detectable, and model the signal as the function of the source shape of the source, its internal brightness and the lensing mass distribution. Now, if the source is a quasar, the radiations are mainly dominated by the accretion disc close to the supermassive black hole horizon.

The motivation of this work is to demonstrate if one assumes a parametric form for the shape (surface brightness 2D) of the accretion disk of the supermassive black hole, is it possible to recover the 2D brightness profile by looking at the brightness of the source over a range of time.

2 THEORY

2.1 Basic microlensing theory

We start by introducing in a succint manner the gravitational lensing theory that is relevant for microlensing in general and for the scope of the present paper in particular. For a detailed presentation of the theory the reader is referrend to the books and articles that represent the references of the current section (book by Schneider and others).

The general microlensing equation can be written as:

$$\vec{y} = \begin{pmatrix} 1-\gamma-k & 0 \\ 0 & 1+\gamma-k \end{pmatrix} \vec{x} - \sum_{i=1}^{n} m_i \frac{\vec{x}-\vec{x_i}}{(\vec{x}-\vec{x_i})^2}. \quad (1)$$

The equation is valid for a set of n point (Schwarzschild) lenses placed at coordinates $\vec{x_i}$. $\vec{y}$ represents the coordinates in the source plane for the respective ray, while $\vec{x}$ represents the coordinates in the lens plane. Furthermore, γ and k are the shear and surface mass density.

For the lens mapping a Jacobian can be defined:

$$A(\vec{x}) = \begin{pmatrix} \frac{\partial y_1}{\partial x_1} & \frac{\partial y_1}{\partial x_2} \\ \frac{\partial y_2}{\partial x_1} & \frac{\partial y_2}{\partial x_2} \end{pmatrix}. \quad (2)$$

The determinant of $A(\vec{x})$ is related to the local magnification factor through the equation:

$$\mu(\vec{x}) = \left| \frac{1}{det(A(\vec{x}))} \right| \quad (3)$$

According to this equation, from an infinitesimally small source positioned at $\vec{x}$ in the lens plane an observed will receive a flux $\mu(\vec{x})dF$ instead of the flux dF that would be observed in the absence of the gravitational lens. Therefore the source will dim or brighten depending on whether $\mu(\vec{x})$ is subunitary or supraunitary.

In general, for a single infinitesimally small source more than one image can be observed, each with magnification μ_j. For microlensing events the angular sizes of the images cannot be resolved. The only observable is the flux to which all nearby images contribute. A total magnification

$$\mu_p = \sum_j \mu_j \quad (4)$$

can be defined and account for an increase/decrease of brightness from all images.

2.2 Magnification of a point source near a fold

The determinant of the Jacobian A can have both positive and negative values depending in which region it is computed.Such regions are well defined and separated by critical curves where the determinant vanishes. The lens equation maps the critical curves of the lens plane into caustics in the source plane. An example of the caustic shape can be seen in the magnification map of ———Figure 1———.

————————————————————————
——————Figure 1——————
————————————————————————

Along these critical curves in the lens plane or caustics in the source plane, the magnification μ is infinite, a result that simply follows from equation ((3). This statement holds only fo infinitesimally small sources. For extended sources the maximum amplification is finite since only an infinitesimally small area of the source overlaps with the caustics (Schneider Weiss 1986 paper others).

The matrix A at the coordinates of the caustic can have rank 1 or rank 0. If the rank is 1 then the coordinates belong to $fold$ or $cusp$ singularities. For the purpose of this paper we are interested only in the behaviour around $fold$ singularities. A condition necessary to distinguish between a fold and cusp singularities is that the eigenvector of A corresponding to the null eigenvalue is not a tangent vector of the critical curve (Dominik 2008, Schneider Weiss 1992).

————————————————————————
——————Figure 2——————
————————————————————————

The behaviour of the images of a point source and their corresponding magnifications near such a caustic has been thoroughly studied in the past.

3 SOURCE SHAPE MODELS

3.1 The crescent

3.2 The uniform disk

3.3 The Gaussian disk

4 MODEL FITTING

5 DISCUSSION

(Liesenborgs et al. 2006)

REFERENCES

Liesenborgs J., De Rijcke S., Dejonghe H., 2006, MNRAS, 367, 1209