Microlensing probes the AGN structure of the lensed quasar J1131-1231

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Lensing theory

(Credit: Courbin, Saha, Schechter 2003)
\[ R_E = \sqrt{\frac{4GM}{c^2}} \frac{D_{ls}D_{os}}{D_{ol}} = 14.3 \sqrt{\frac{Mh^{-1}}{M_\odot}} \text{ lt - days} \]

For \( z_s = 0.66 \) \( z_l = 0.29 \)

\[ \Rightarrow \theta_E = \frac{R_E}{D_{os}} \approx 1 \mu\text{arcsec} \]
Lensing theory

Regions with sizes $\leq R_E$ are (de)magnified by the microlens.

The effect is dynamic => changes on time scale of months up to years.
The target

Name: J1131-1231

$z_{\text{lens}} = 0.295$

$z_{\text{source}} = 0.657$

$\Delta t_{\text{AC/AB}} < 5 \text{ days}$

$V \sim 17.5 \text{ mag}$

HST color image (F555W-F814W-F160W)
The data

FORS2 GR600B/I; R=800/1500
F_μ decomposition

Original spectrum: F = F_M + F_{Mμ}

If image 1 is affected by some microlensing μ, and if M = M_1/M_2 one can write:

\[ F_1 = M F_M + M \mu F_{Mμ} \]
\[ F_2 = F_M + F_{Mμ} \]

\[ F_M = \frac{F_1 / M - \mu F_2}{1 - \mu} \]
\[ F_{Mμ} = \frac{F_2 - F_1 / M}{1 - \mu} \]
Microlensing in image A

\[ \frac{M_A}{M_B} = 2.1 \]

\[ \mu = 0.3 \]
Microlensing in image C

\[ M_C/M_B = 1.4 \]

\[ \mu = 0.25 \]
Emission

In A, only a fraction of BLR micro-lensed, while nearly whole BLR micro-lensed in C.

⇒ $R_E$ (micro in C) > $R_E$ (micro in A)

<table>
<thead>
<tr>
<th>S&lt;$R_E$(A)&lt;$R_E$(C)</th>
<th>$R_E$(A)&lt;S&lt;$R_E$(C)</th>
<th>$R_E$(A)&lt;$R_E$(C)&lt;S</th>
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</thead>
<tbody>
<tr>
<td>* VBC in MgII</td>
<td>* Main part BLR</td>
<td>* Core of BLR</td>
</tr>
<tr>
<td>* Fell in SBB</td>
<td>* Main part of Fell opt/UV</td>
<td></td>
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<tr>
<td>* Fell ~ 4600Å</td>
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Absorbers

Absorbed flux proportional to cont.+BLR
⇒ Absorber exterior to cont.+BLR
Absorbers

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Normal

\[ \mu \text{lens} \]
Absorbers

Absorption identical for all the lensed images indicates that spatial distribution and optical depth of the absorber is quite homogeneous (to be quantified through modelling)
Summary

- Micro-lensing enables one to probe the AGN structures on spatial scales of < 1 \( \mu \)arcsec (i.e. up to BLR size)
- In J1131-1231, two micro-lensing events in 2 different lensed images from which we inferred:
  1. VBC emitting region of MgII is very compact
  2. FeII emission in the red part of SBB and around 4600Å is very compact
  3. More compact regions of the BLR have larger FWHM
  4. Main part of FeII opt/UV is emitted in a region similar to BLR
  5. Spatial distribution and \( \tau \) of absorber is homogeneous

More in astro-ph/0703030; (Sluse, Claeskens, Hutsemekers, Surdej)
Perspectives

• More quantitative information should be gained from a spectro-photometric monitoring ⇒ properly characterize the micro-lensing event; retrieve absolute size of the μlensed regions; possibly probe the BLR kinematics

• Modelling of micro-lensing of the BLR (partly performed by e.g. Abajas et al. 2002; Lewis and Ibata 2004) and of the absorbers

More in astro-ph/0703030; (Sluse, Claeskens, Hutsemekers, Surdej)
Absorbers

- $I_{\text{blue}} = e^{-\tau}$ and $I_{\text{red}} = e^{-0.5\tau}$ if uniform coverage

- $I_{\text{red}}^2 < I_{\text{blue}} \Rightarrow$ partial coverage of 20%
Absorbers

\[ F_1 = x + y - A_1 \quad \text{and} \quad F_2 = M(x + \mu y) - A_2 \]

i) \( A_1 = a_\lambda (x + y) \) or ii) \( A_1 = a_\lambda x \)

i) \( A_2 = a_\lambda M(x + \mu y) \) or ii) \( A_2 = a_\lambda Mx \)

Imagine that reality = case (i)

\[ F_1^{\text{norm}} = 1 - A_1 / (x + y) = 1 - a_\lambda \]

\[ F_2^{\text{norm}} = 1 - A_2 / (M(x + \mu y)) = 1 - a_\lambda \]

If we had normalized by \( x \) then \( F_1^{\text{norm}} \neq F_2^{\text{norm}} \)
Lensing theory

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