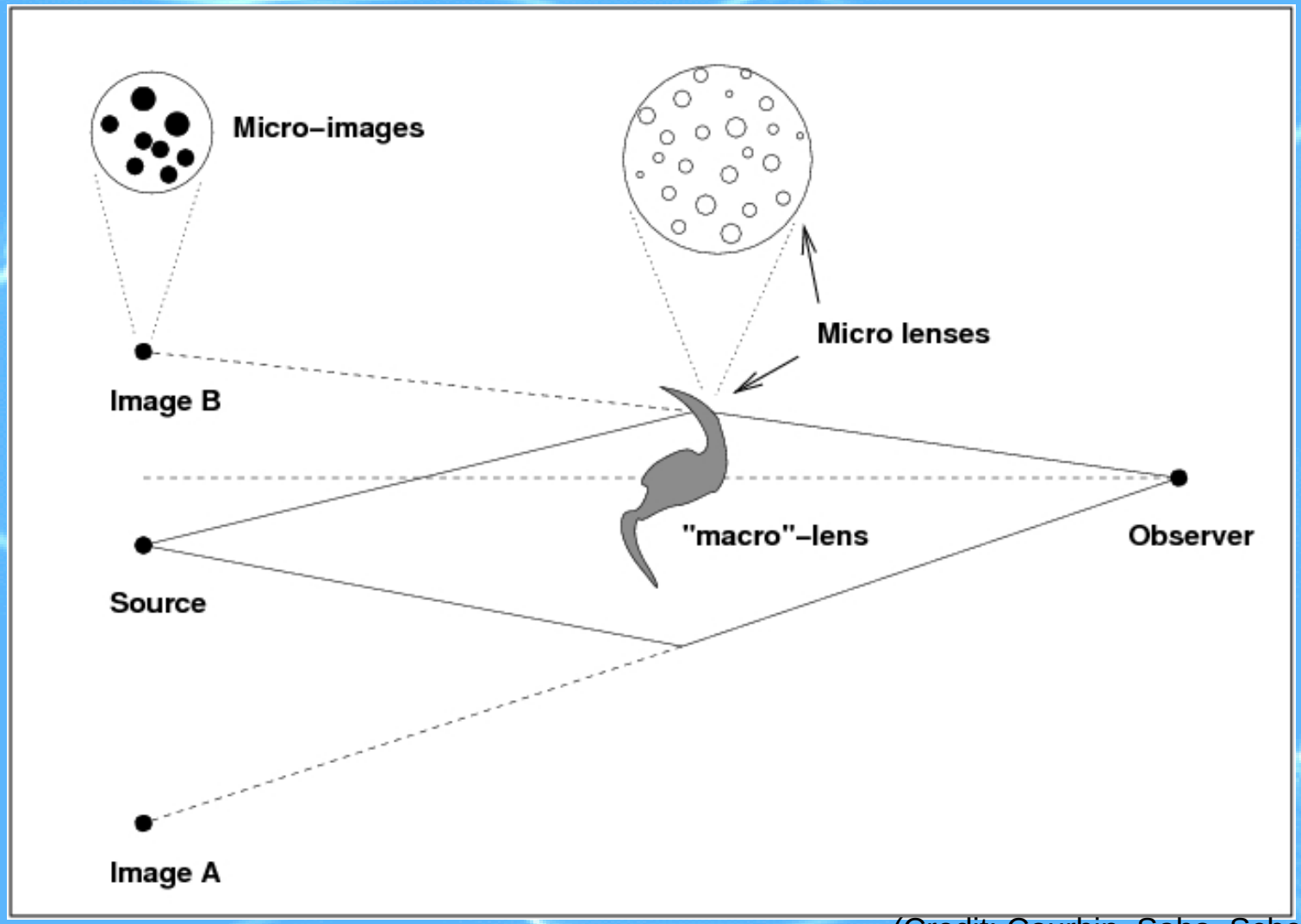
# Microlensing probes the AGN structure of the lensed quasar J1131-1231

Dominique Sluse (EPFL, Switzerland)

In collaboration with J-F. Claeskens, D.Hutsemékers, J. Surdej

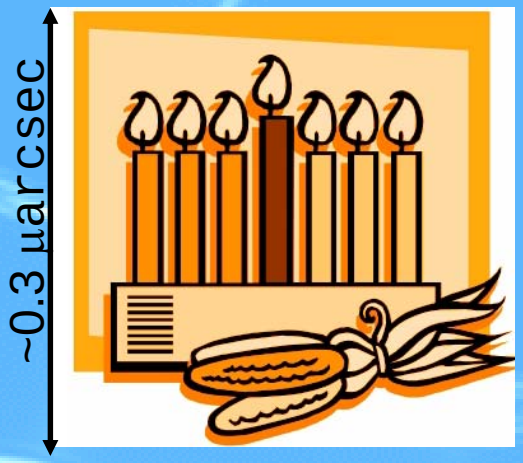
Huatulco, April 19, 2007

# Lensing theory




(Credit: Courbin, Saha, Schechter 2003)

# Lensing theory





$$R_E = \sqrt{\frac{4GM}{c^2}\frac{D_{ls}D_{os}}{D_{ol}}} = 14.3\sqrt{\frac{Mh^{-1}}{M_\odot}}\,\mathrm{lt-days}$$

$\Rightarrow \theta_E = R_E/D_{os} \sim 1\mu$arcsec

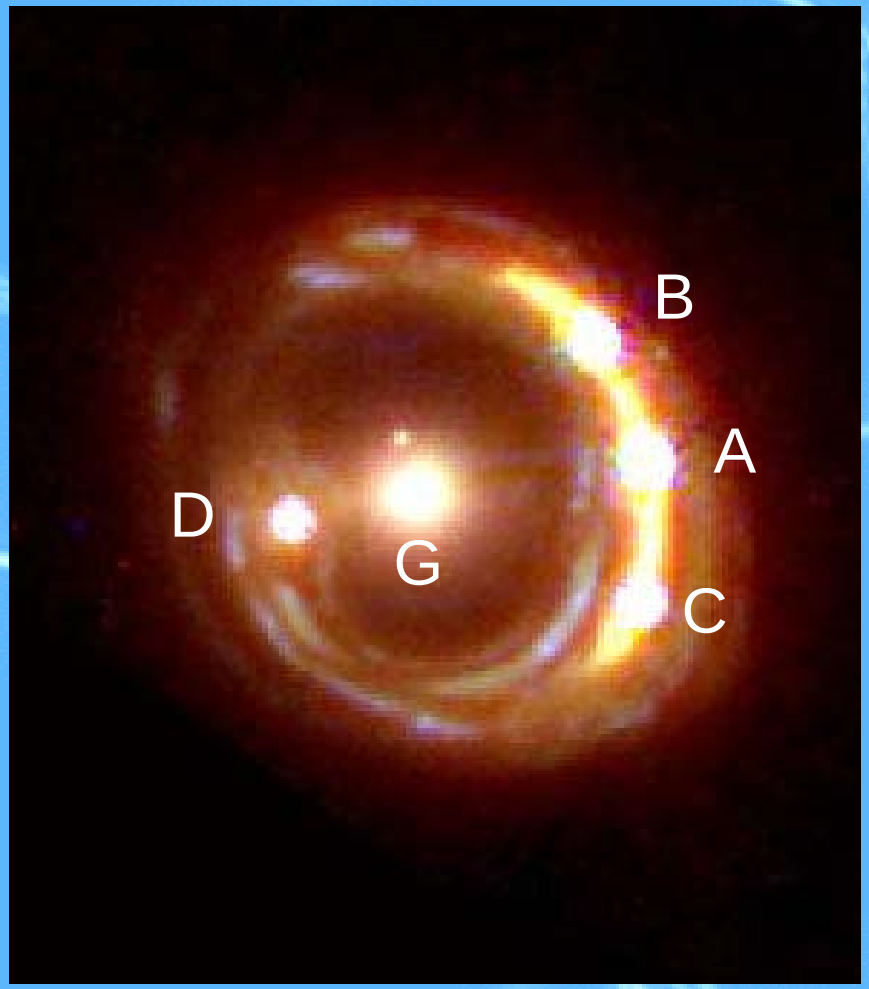
For $z_s$=0.66 $z_l$=0.29

# 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

$z_{lens} = 0.295$

$z_{source} = 0.657$

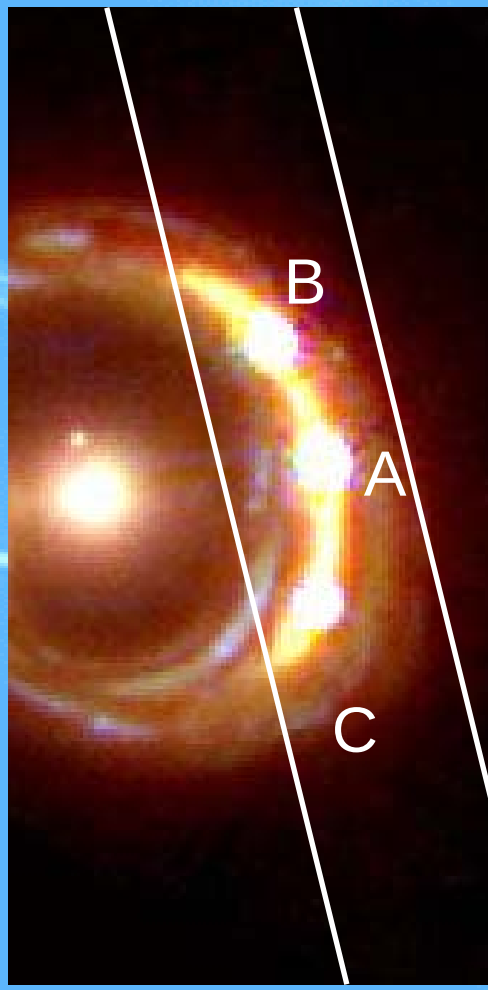
$\Delta t_{AC/AB} < 5$ days

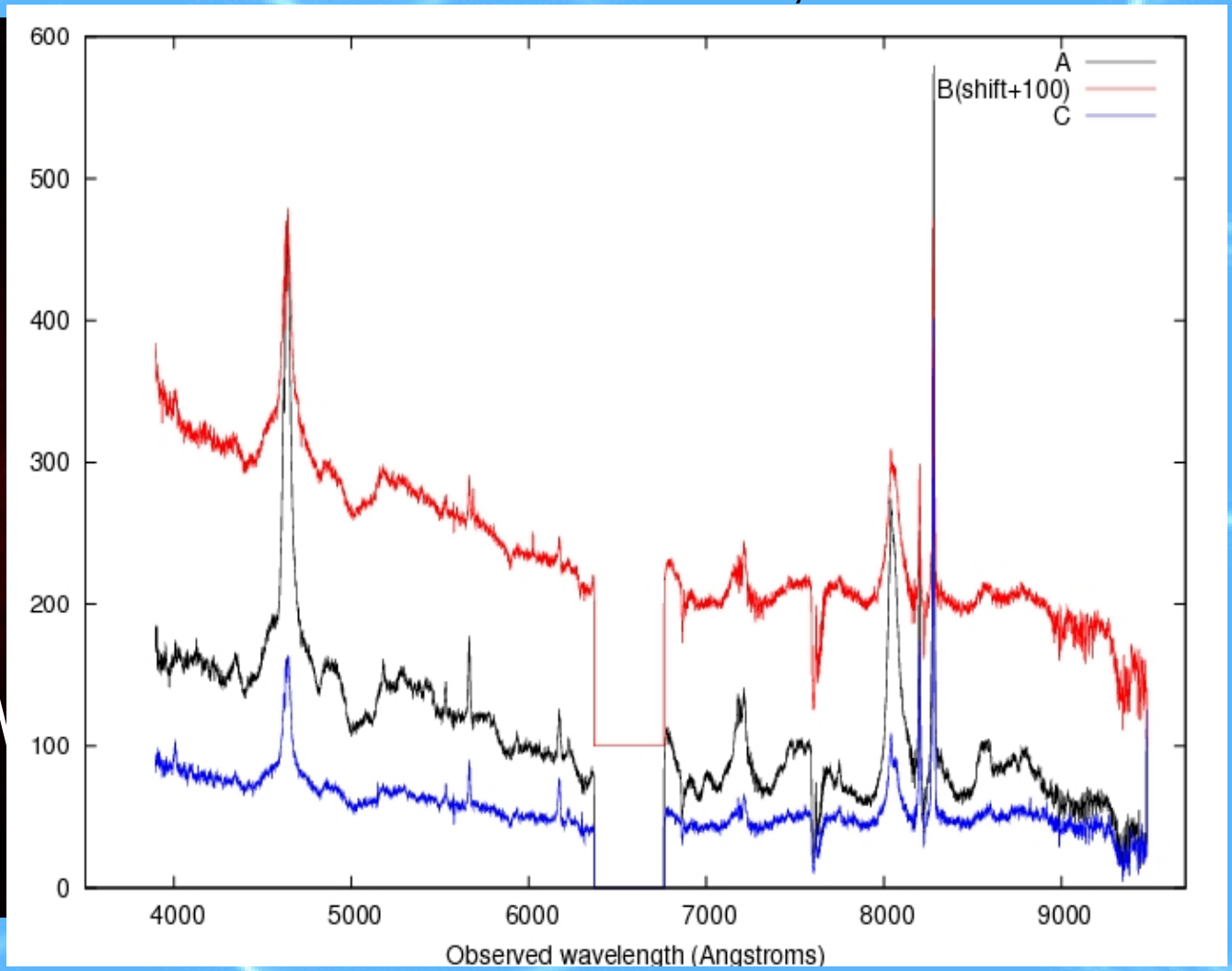
V ~ 17.5 mag

HST color image (F555W-F814W-F160W)

# The data

FORS2 GR600B/I; R=800/1500



# $F\mu$ decomposition

Original spectrum: $F = F_M + F_{M\mu}$

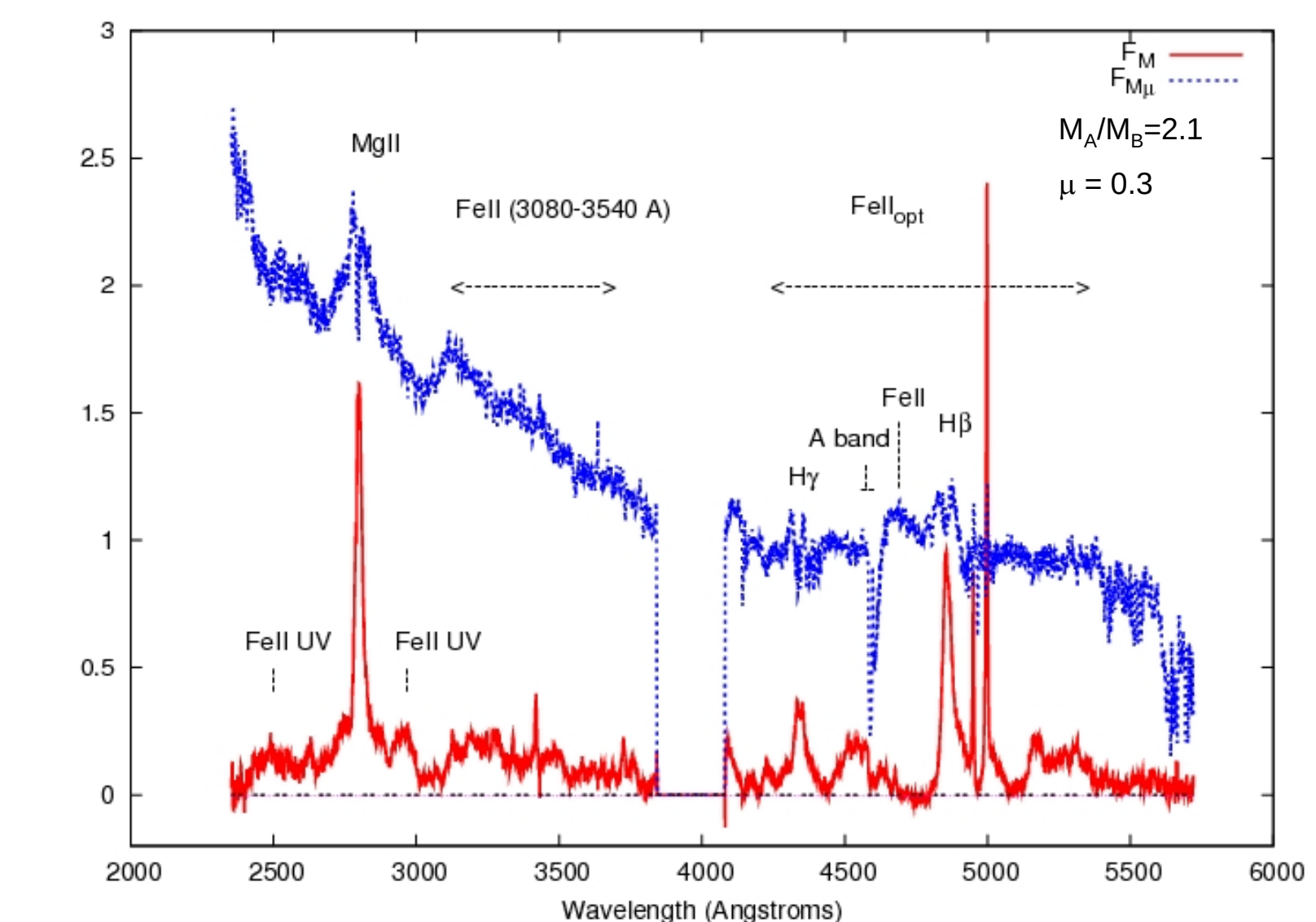
If image 1 is affected by some micro-lensing $\mu$, and if $M = M_1/M_2$ one can write:

$F_1 = M\, F_M + M\, \mu\, F_{M\mu}$

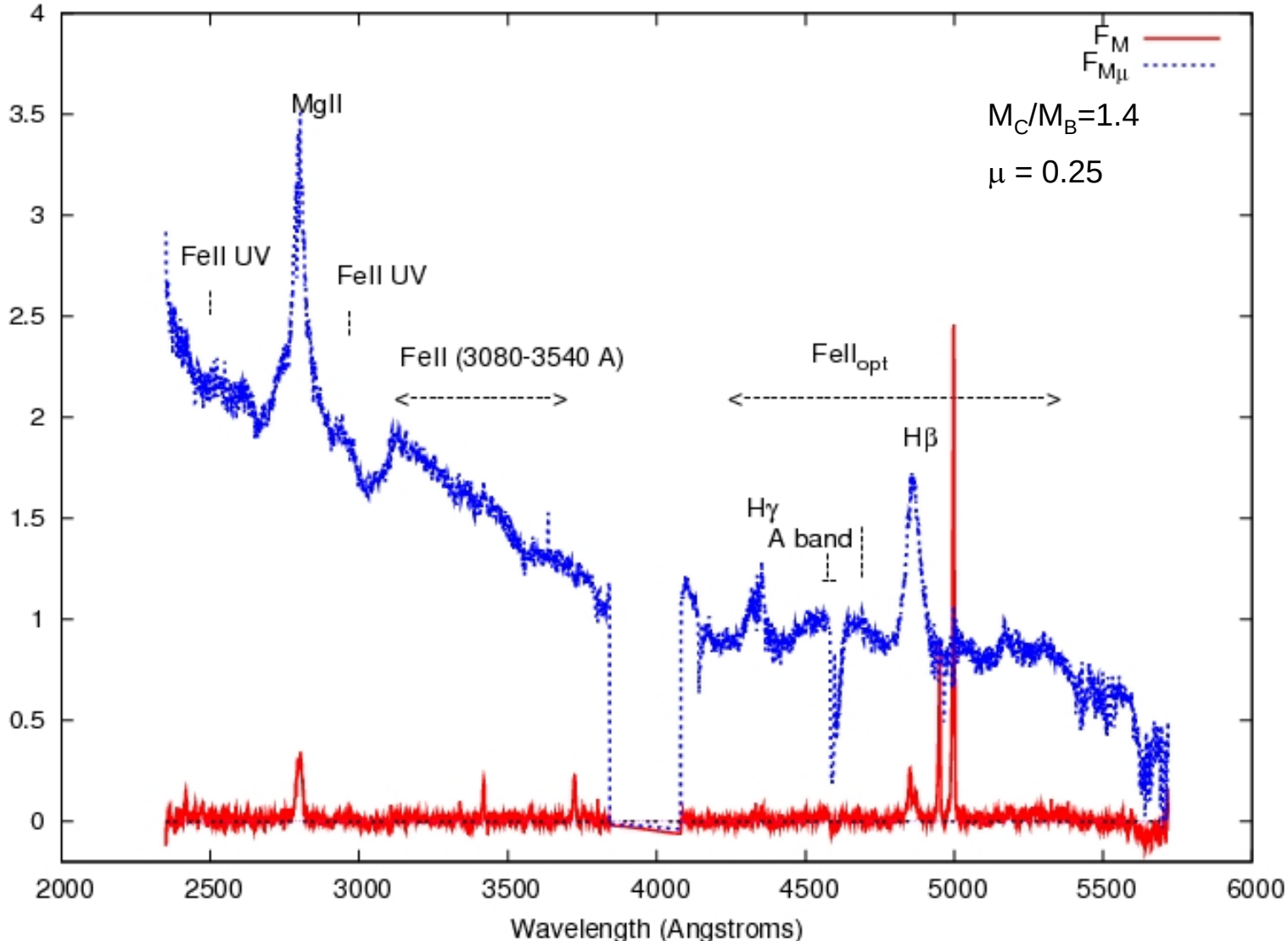
$F_2 = F_M + F_{M\mu}$

$$F_M = \frac{F_1 / M - \mu F_2}{1 - \mu} \qquad F_{M\mu} = \frac{F_2 - F_1 / M}{1 - \mu}$$

# Microlensing in image A



# Microlensing in image C



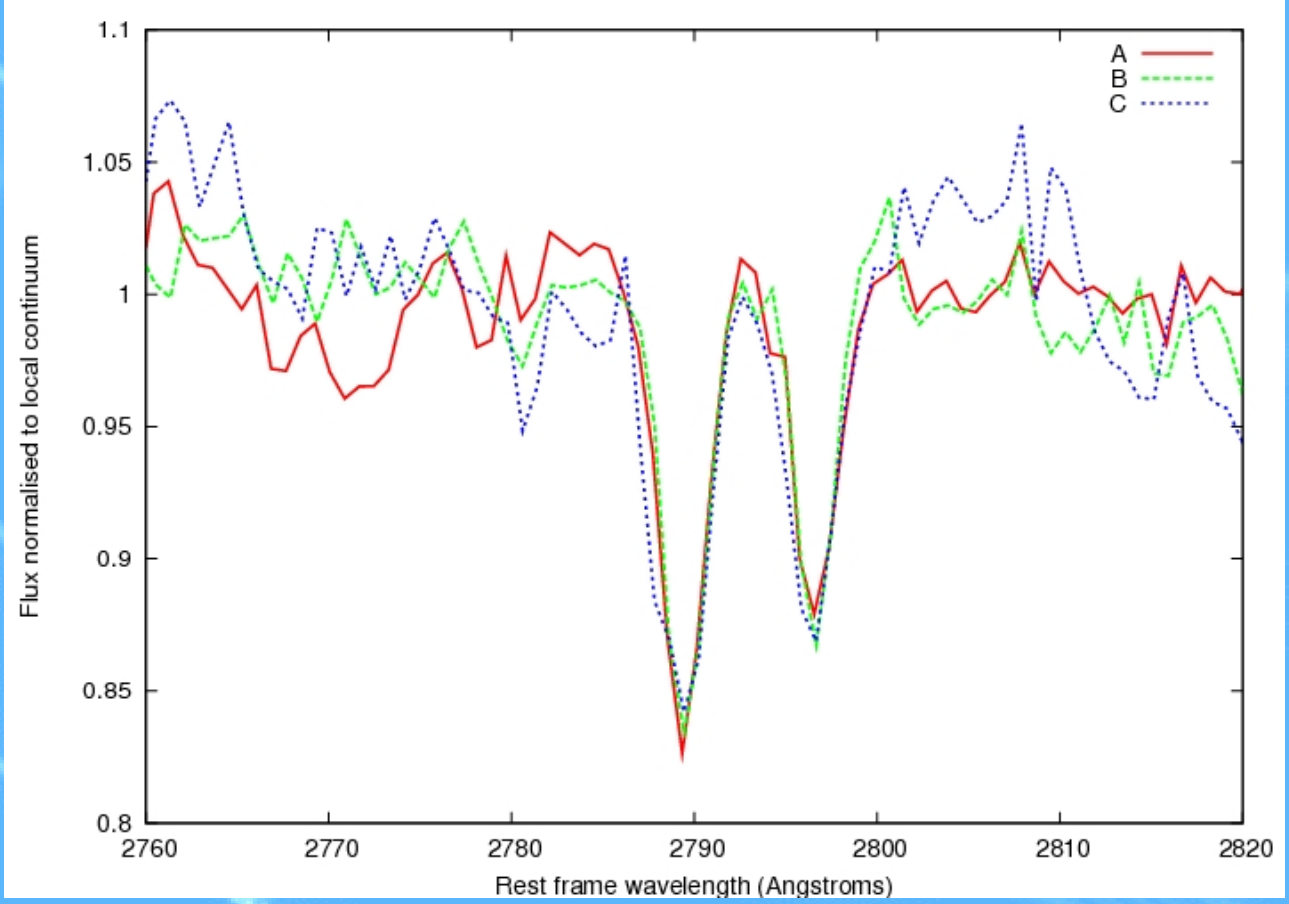
# Emission

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

$\Rightarrow R_E$ (micro in C) > $R_E$ (micro in A)

| $S<R_E(A)<R_E(C)$ | $R_E(A)<S<R_E(C)$ | $R_E(A)<R_E(C)<S$ |
|---|---|---|
| * VBC in MgII<br>* FeII in SBB<br>* FeII ~ 4600Å | * Main part BLR<br>* Main part of FeII opt/UV | * Core of BLR |

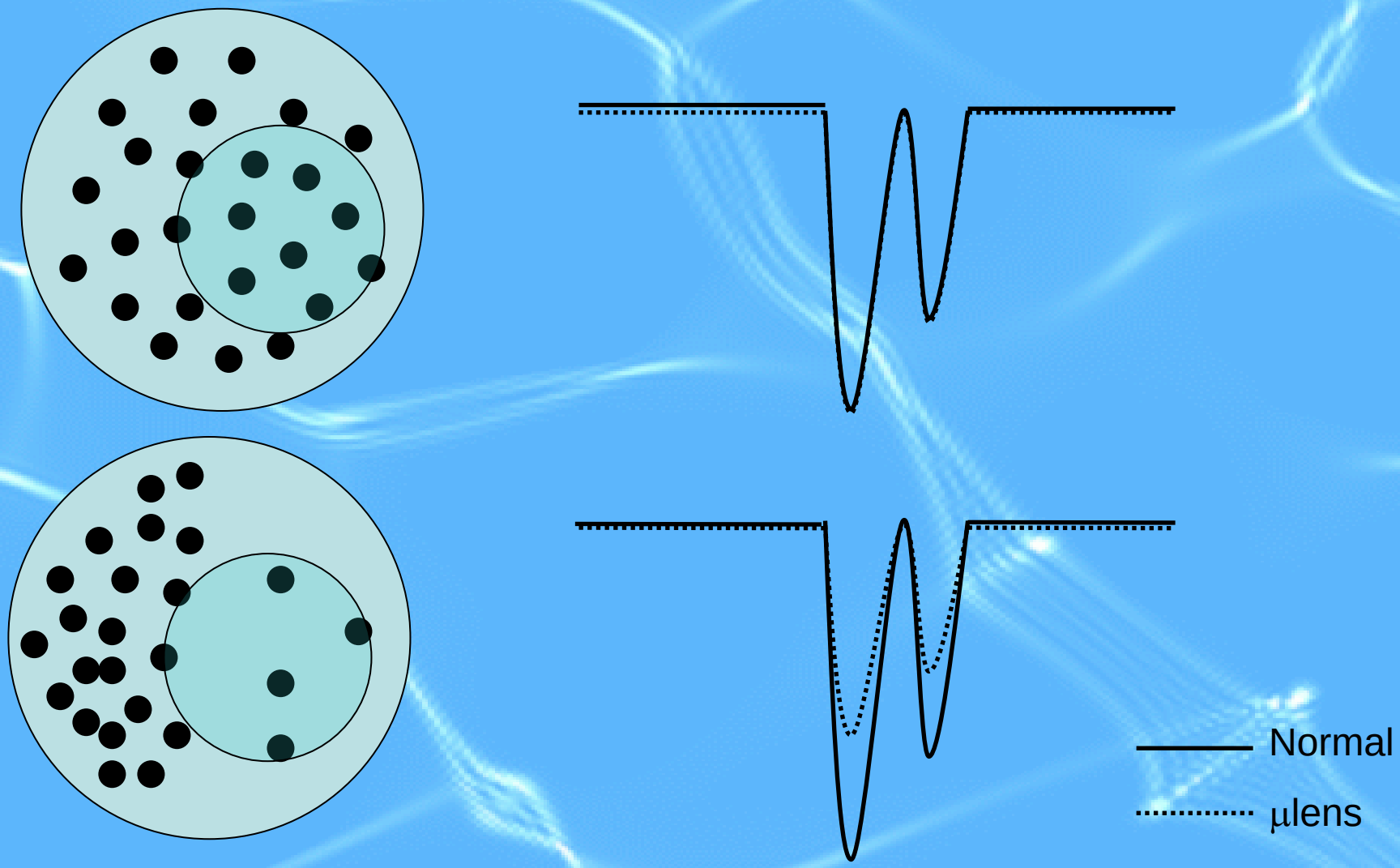
# Absorbers



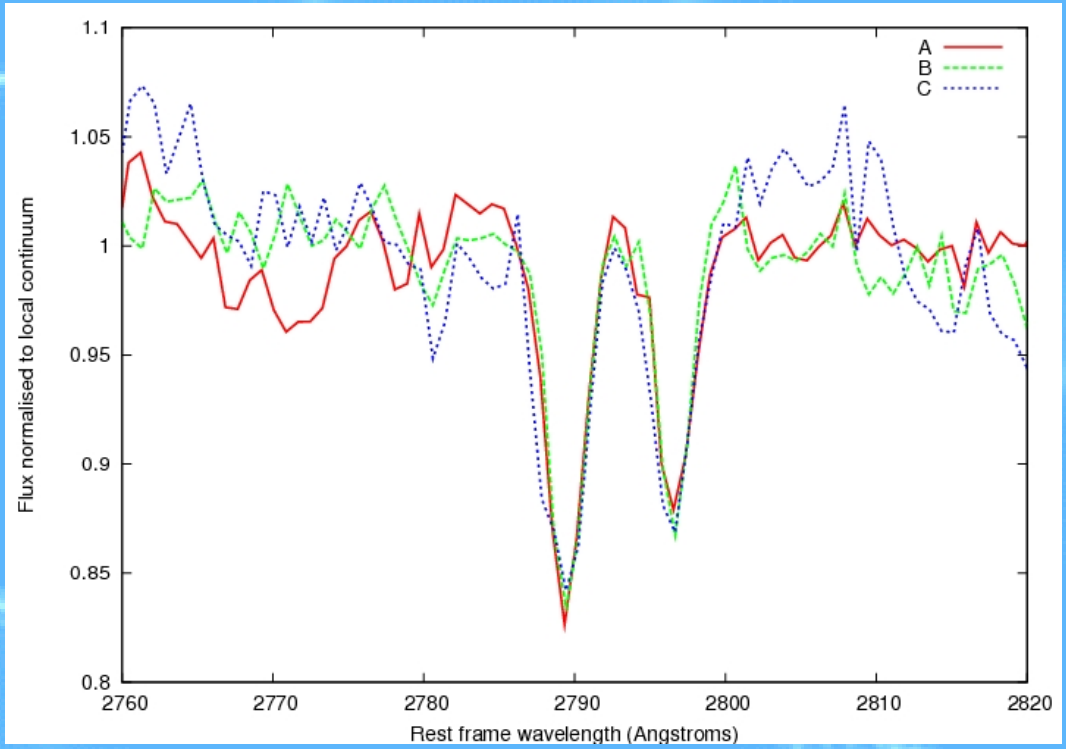

Absorbed flux proportional to cont.+BLR

$\Rightarrow$ Absorber exterior to cont.+BLR

# Absorbers



# 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 μarcsec (i.e. up to BLR size)
- In J1131-1231, two micro-lensing events in 2 different lensed images from which we infered:

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 $\Rightarrow$ properly characterize the micro-lensing event; retrieve absolute size of the $\mu$lensed 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

- $I_{blue} = e^{-\tau}$ and $I_{red} = e^{-0.5\tau}$ if uniform coverage
- $I^2_{red} < I_{blue}$ => partial coverage of 20 %

# Absorbers

$F_1=x+y-A_1$ and $F_2=M(x+\mu y)-A_2$

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)

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

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

If we had normalized by x then $F_1^{norm}\neq F_2^{norm}$

# Lensing theory

~ 3 μarcsec

$$R_E = \sqrt{\frac{4GM}{c^2}\frac{D_{ls}D_{os}}{D_{ol}}} = 14.3\sqrt{\frac{Mh^{-1}}{M_\odot}}\,\mathrm{lt-days}$$

$\Rightarrow \theta_E = R_E/D_{os} \sim 1\mu$arcsec

For $z_s$=0.65 $z_l$=0.29