What can we learn about quasars and unification scheme with the microlensing technique ?

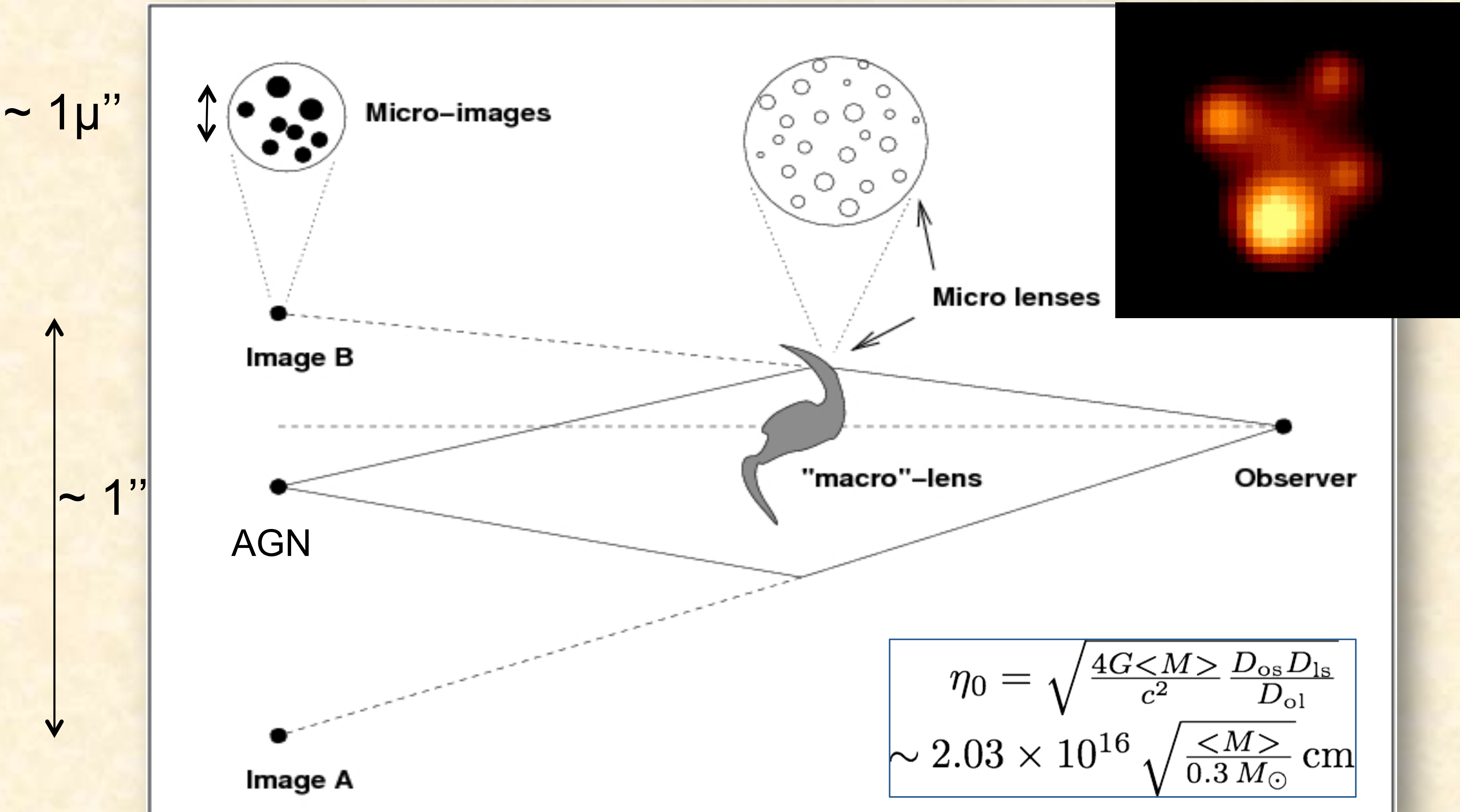
Dominique Sluse

(University of Liège, Belgium)

with T. Anguita (Uni. A. Bello, Chile), L. Braibant, D. Hutsemékers (U. Liège),
P. Riaud, R.W. Schmidt, J. Wambsganss (U. Heidelberg), F. Courbin (EPFL, Lausanne)

Winchester, September 15th 2015

Introduction

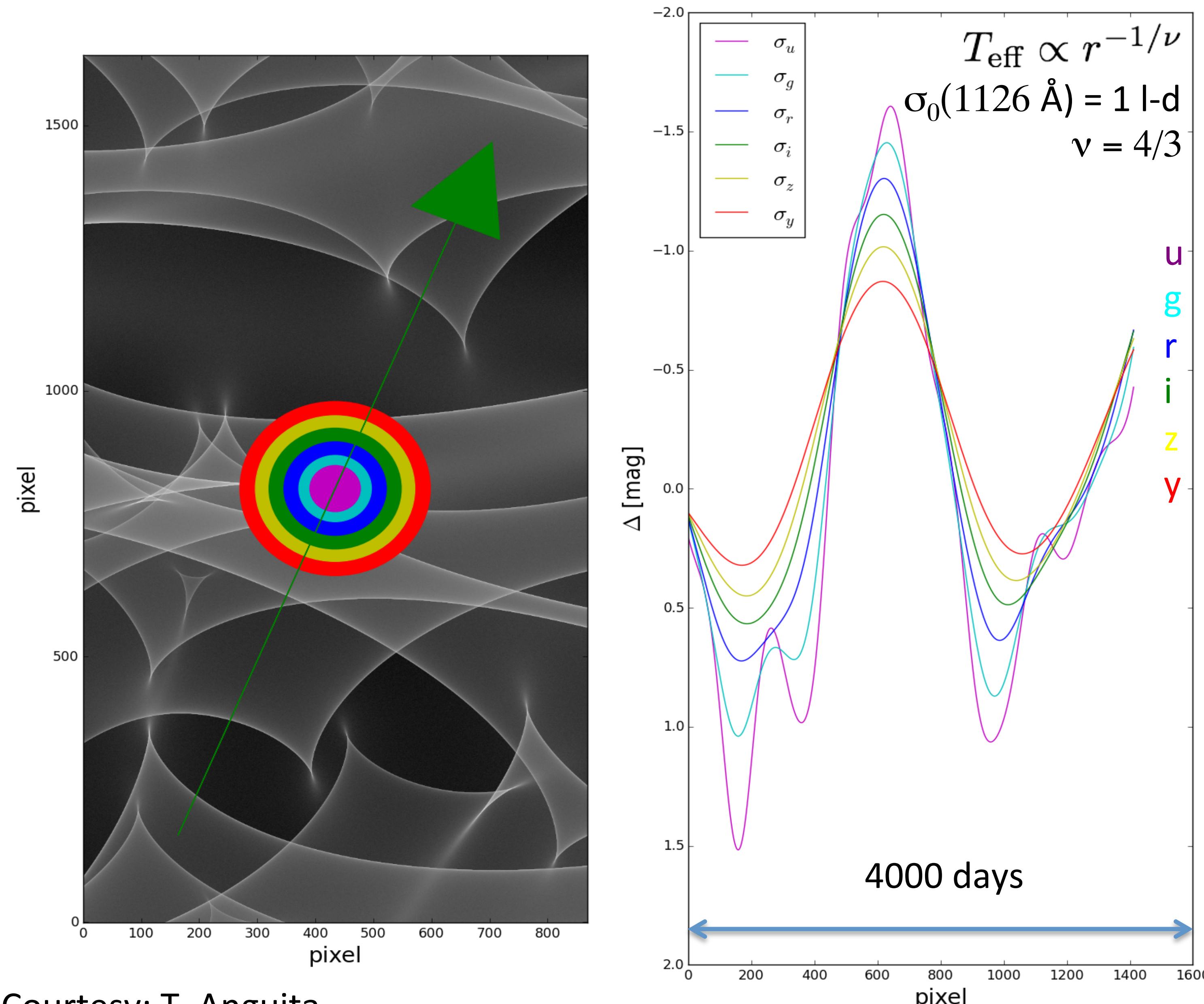


$$\eta_0 = \sqrt{\frac{4G<M>}{c^2}\frac{D_{\rm os}D_{\rm ls}}{D_{\rm ol}}}$$

$$\sim 2.03 \times 10^{16}\sqrt{\frac{<M>}{0.3\,M_\odot}}\ \mathrm{cm}$$

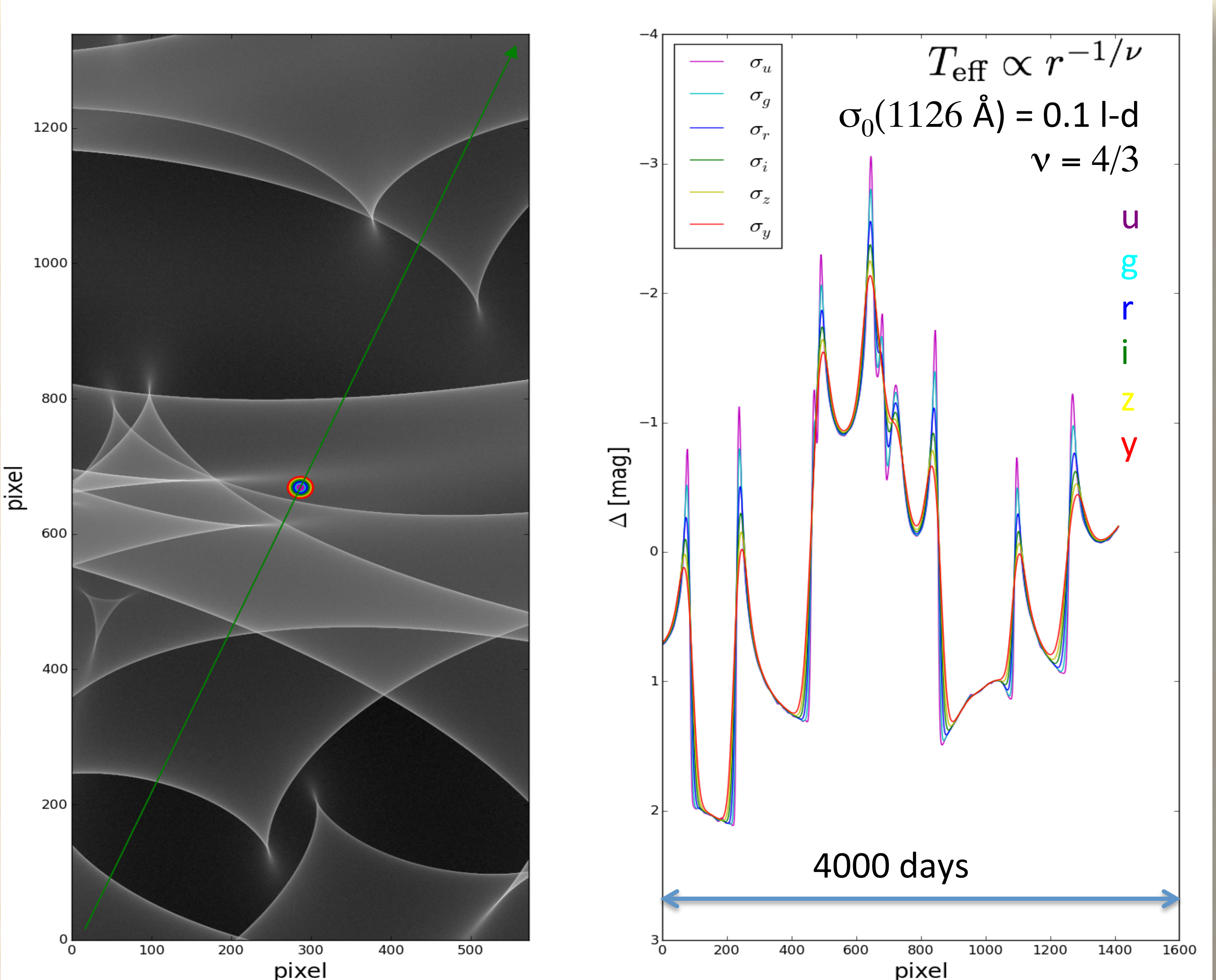
(Credit: Courbin, Saha, Schechter 2003; Claeskens+ 2006)

Introduction



Courtesy: T. Anguita

Introduction



Courtesy: T. Anguita

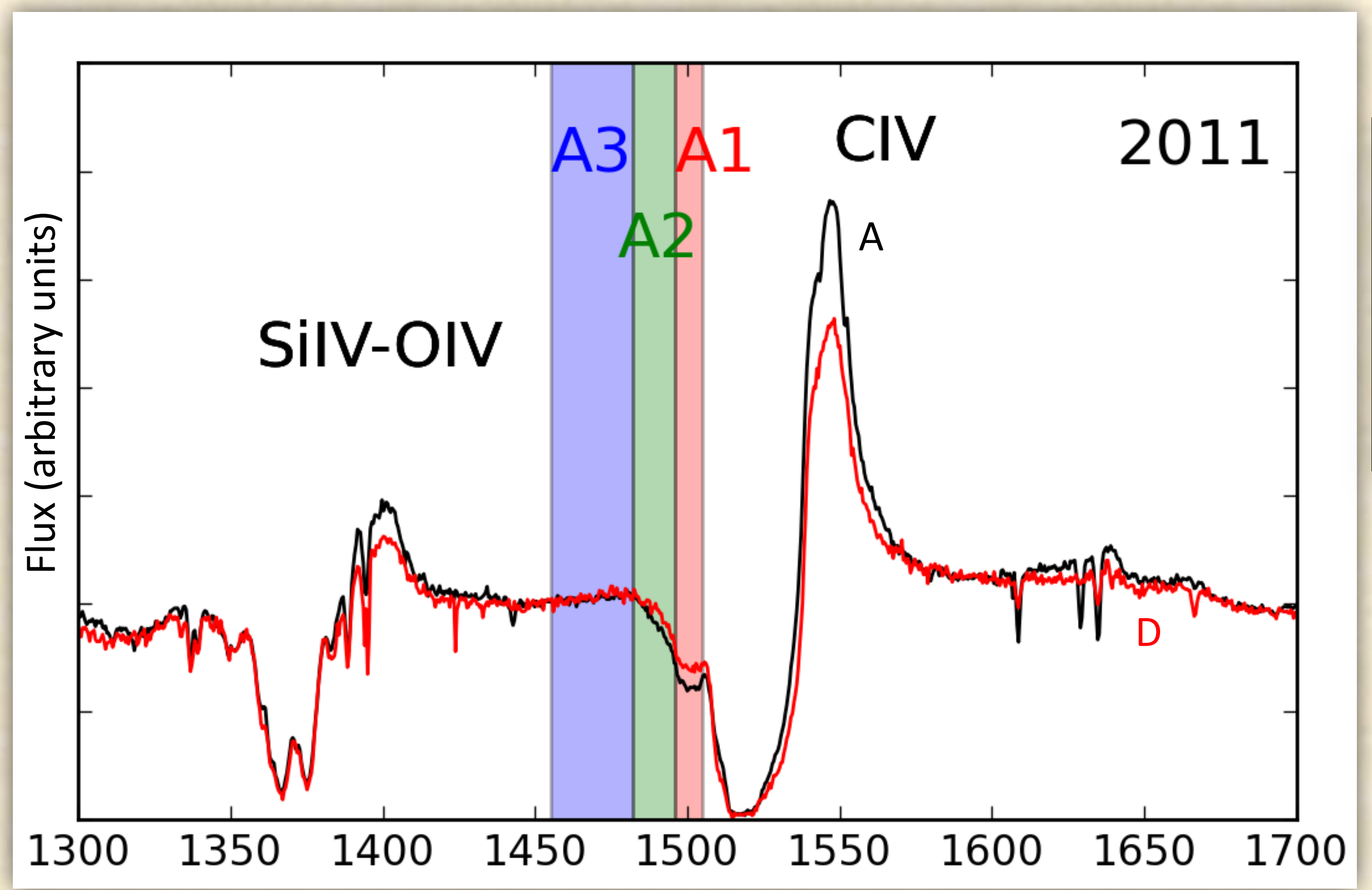
Accretion disk: Size and Temperature

$T_{\mathrm{eff}} \propto r^{-1/\nu} \Rightarrow r \propto \lambda^{\nu}$ w. Standard value: $\nu_{SS} = 4/3$

Work	Characteristics	Size	Slope (ν)
Morgan+ (2010)	Multi-epoch 1 band 11 systems	R_{ML} (2660Å) > 1.8±1.6 R_{ss}	Indirect ν ~ 2.0 $\Rightarrow R_{ML} \sim R_{SS}$
Blackburne+ (2011)	Single epoch 7 bands 12 systems	R_{ML} (1736Å) > 10^{+7}_{-5} R_{ss}	$\nu = 0.17 \pm 0.15 \pm 0.13$
Eigenbrod+ (2008)	Multi-epoch (3yrs) Spectroscopy 1 system	R_{ML} (2000) > $2.3^{+1.7}_{-1.4}$ R_{ss}	$\nu = 1.2 \pm 0.3$
Poindexter+ (2008) Mosquera+ (2011) Blackburne+ (2013)	Multi-epochs Multi-bands Individual systems	$R_{ML} > R_{SS}$	ν Compatible with ν_{SS} But $\nu > \nu_{SS}$ favoured by B13; $\nu < \nu_{SS}$ by P08

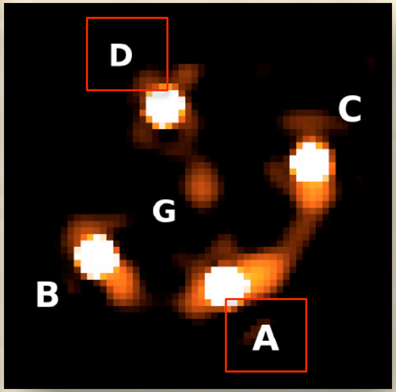
See Hall et al. 2014 MNRAS, 442, 1090 for a summary

Accretion disk: Cloverleaf



Rest-frame wavelength (Å)

H1413+117



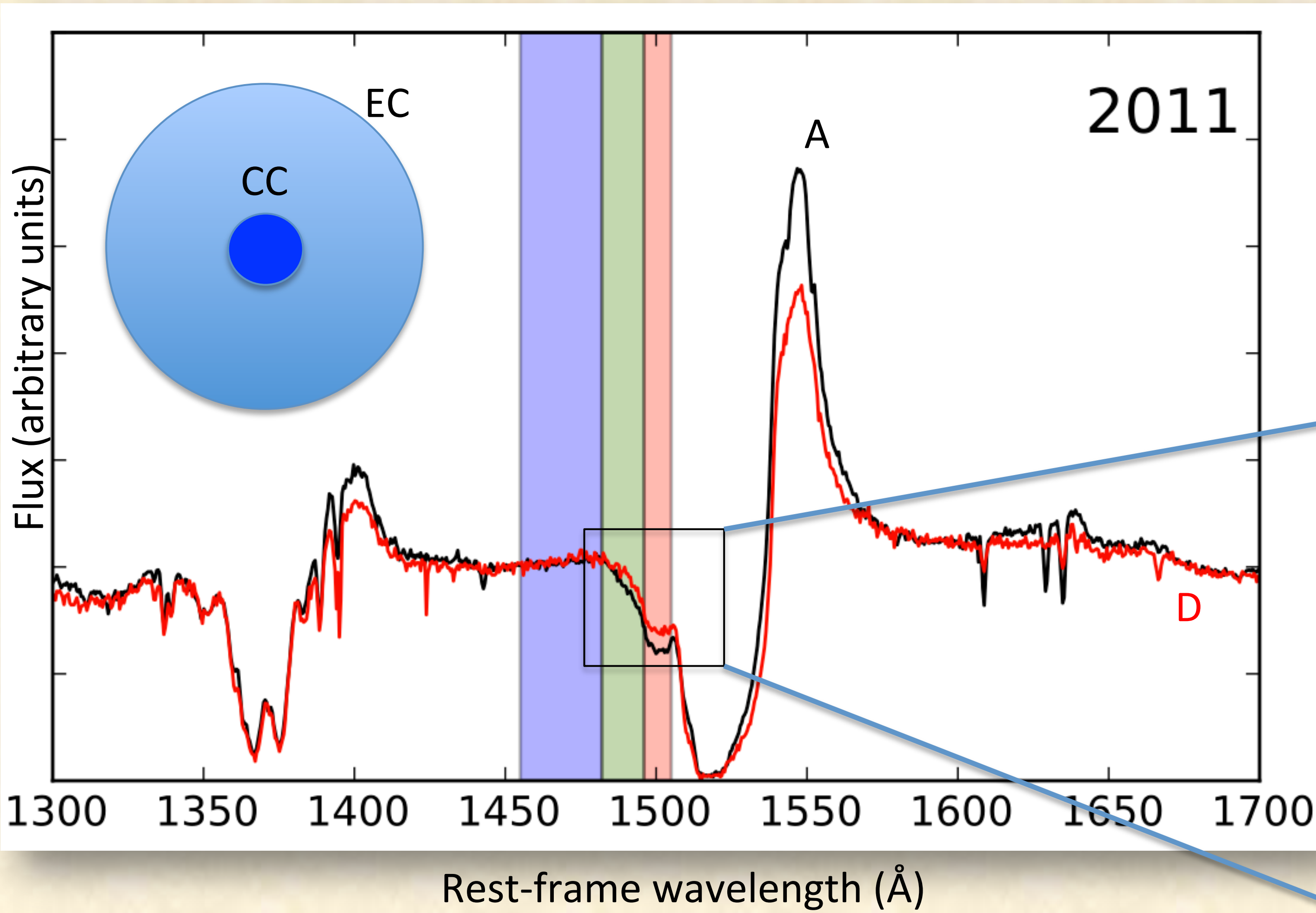
z=2.55

Note that the flux of D is rescaled: D x M/μ

M = Macro magnification
μ = micro magnification

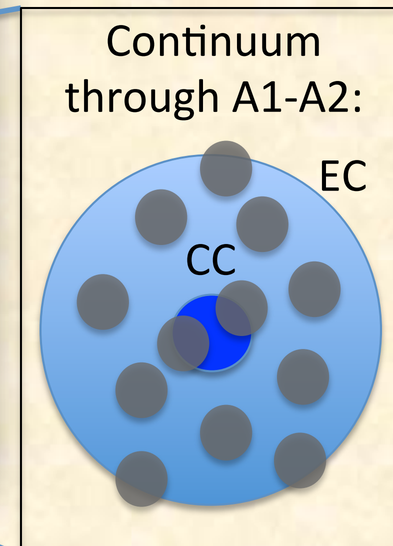
Sluse et al. 2015
arXiv:1508.05394

Accretion disk: Cloverleaf



CC: Compact (SS) continuum

EC: "Extended" (scattered) continuum



Note that the flux of D is rescaled: D x M/μ

M = Macro magnification
μ = micro magnification

Sluse et al. 2015
arXiv:1508.05394

Accretion disk: "Extended" / scattered continuum

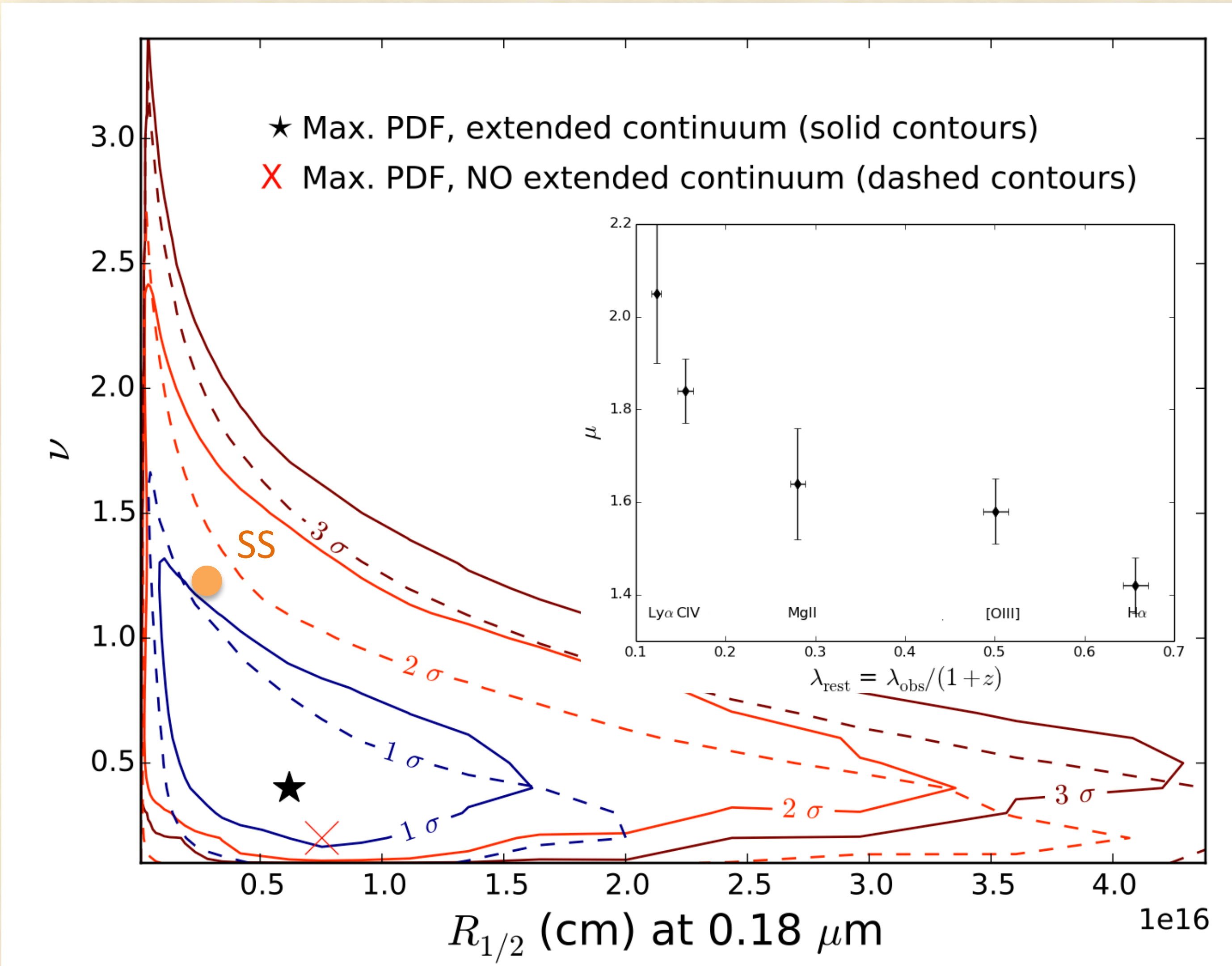
Properties:

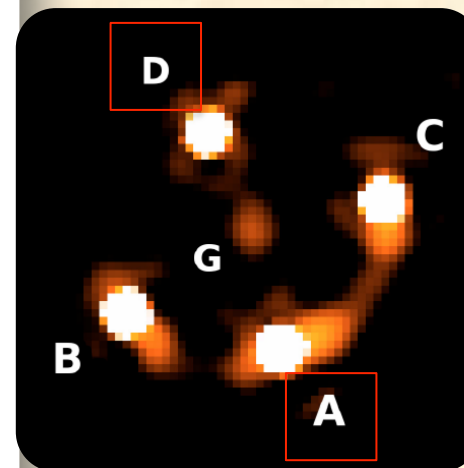
- About 30% of the total UV-continuum flux (could be *in principle* larger)
- Chromaticity: Same amount detected around $\lambda \sim 1216$ Å and $\lambda \sim 1549$ Å (thanks to ML and to the absorber in Lyα and CIV).
- Time variability: Fraction of flux which comes from ''extended'' continuum could vary with time (20% of the total UV-continuum in 2000).
- No (little) ''extended'' continuum at $\lambda \sim 4861$ Å ? (No change of μ at 4861 Å between 2005 and 2011 despite of a change of the effective μ in the UV).
- Emitted on scales smaller than the host galaxy. Could be (polar) scattered light at the origin of polarization also observed in this object (Hutsemékers et al., submitted)

Sluse et al. 2015 arXiv:1508.05394

Accretion disk: Compact continuum

H1413+117

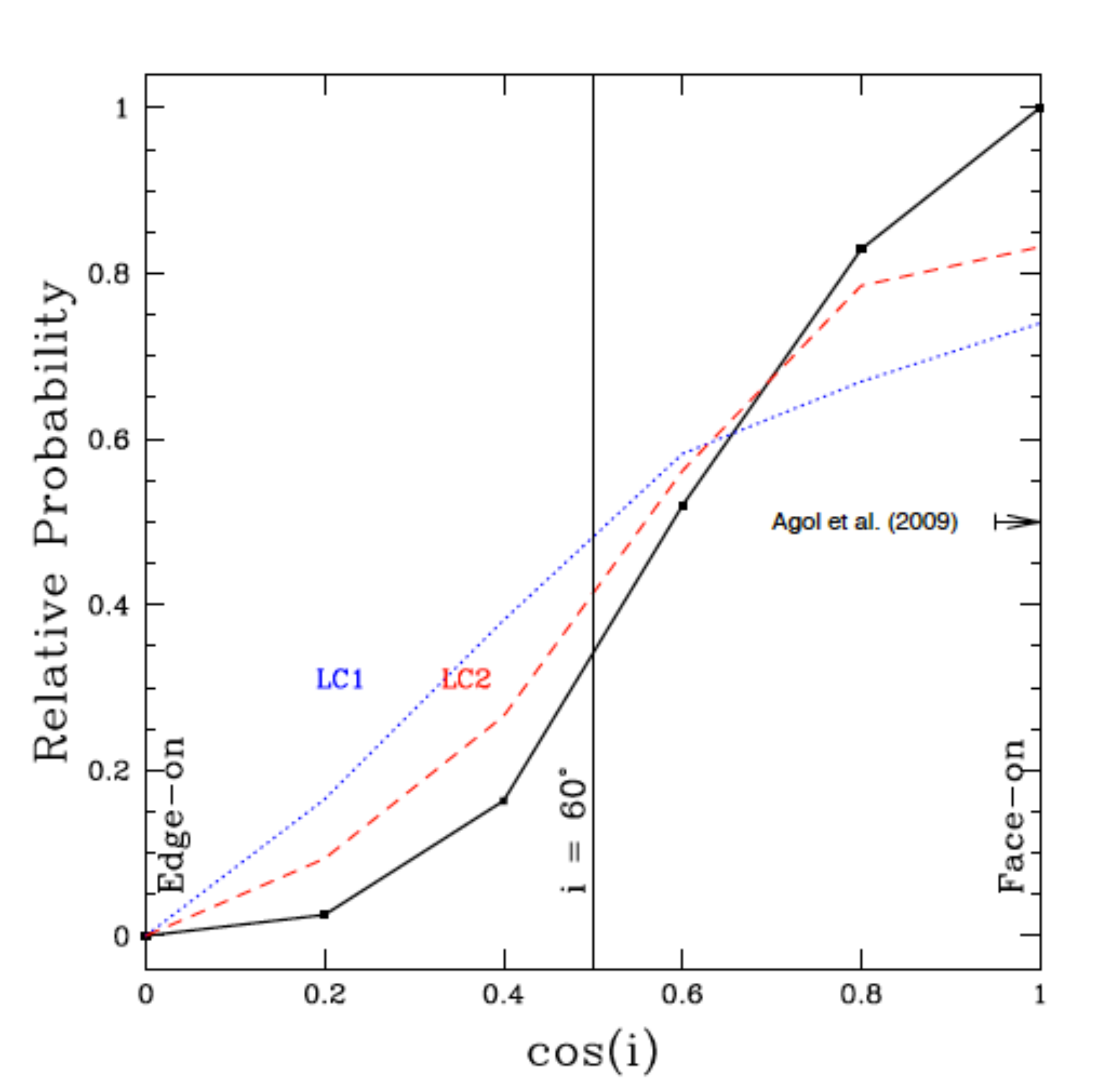




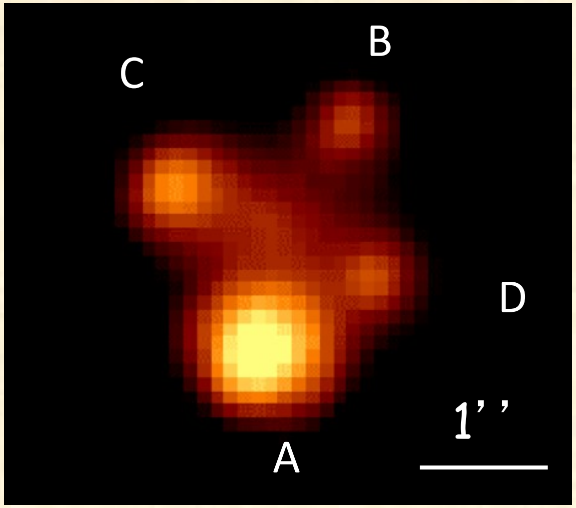
Little impact of extended continuum on the analysis

Sluse et al. 2015 arXiv:1508.05394

Accretion disk: Orientation (literature results)



Analysis of Einstein cross



$z_s = 1.695$ $z_l = 0.039$

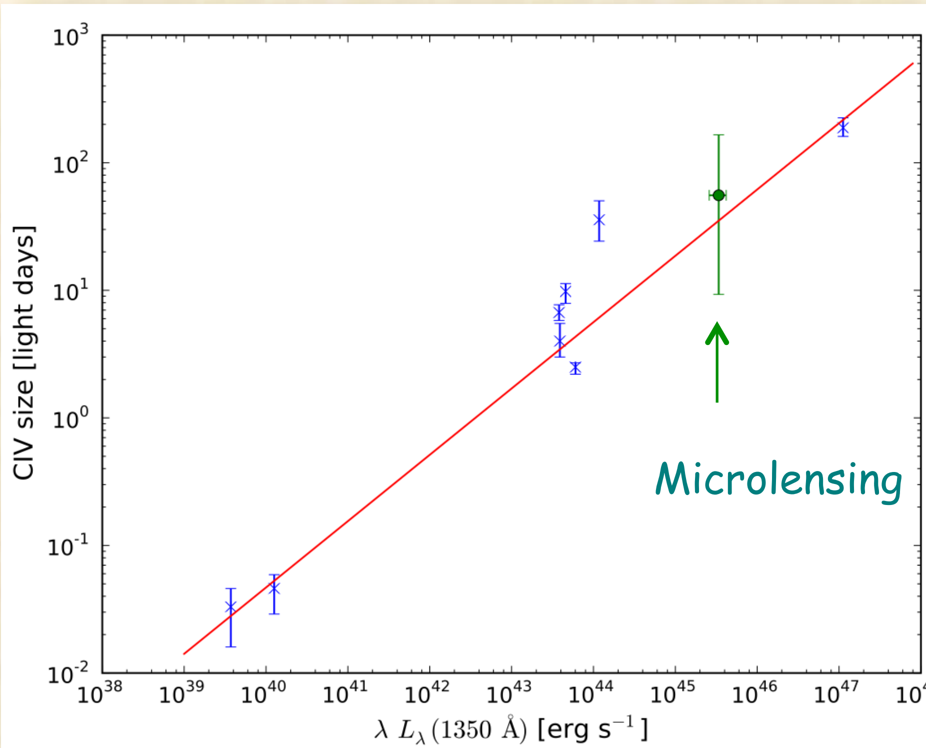
11 years lightcurve (from OGLE)
Splitted in 2 (LC1 and LC2)

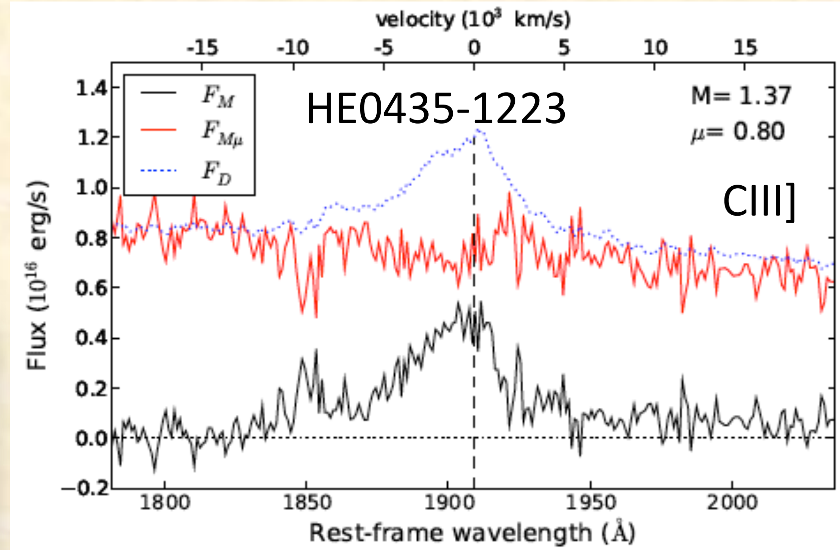
See also Blackburne+ 2013 for cos(i) in HE1104-1805

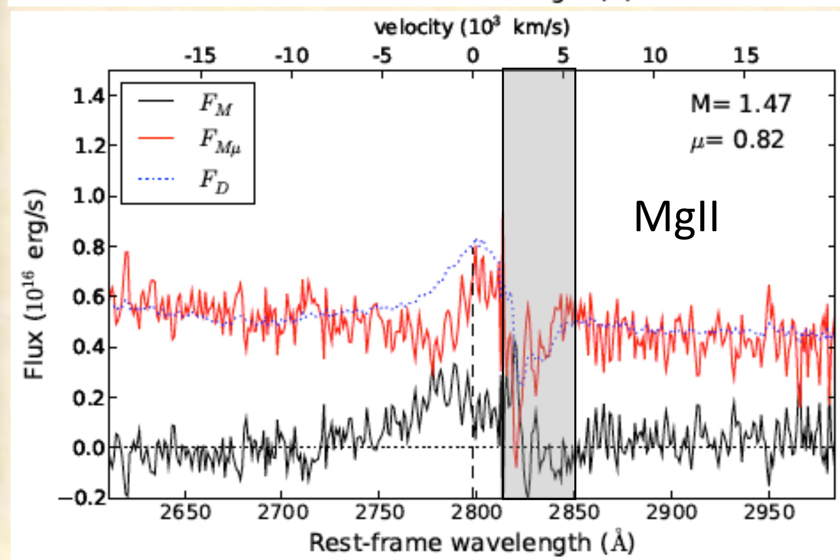
Poindexter and Kochanek 2010, ApJ, 712, 668

BLR: Size and geometry

ML size of the CIV in the Einstein cross compared w. RM





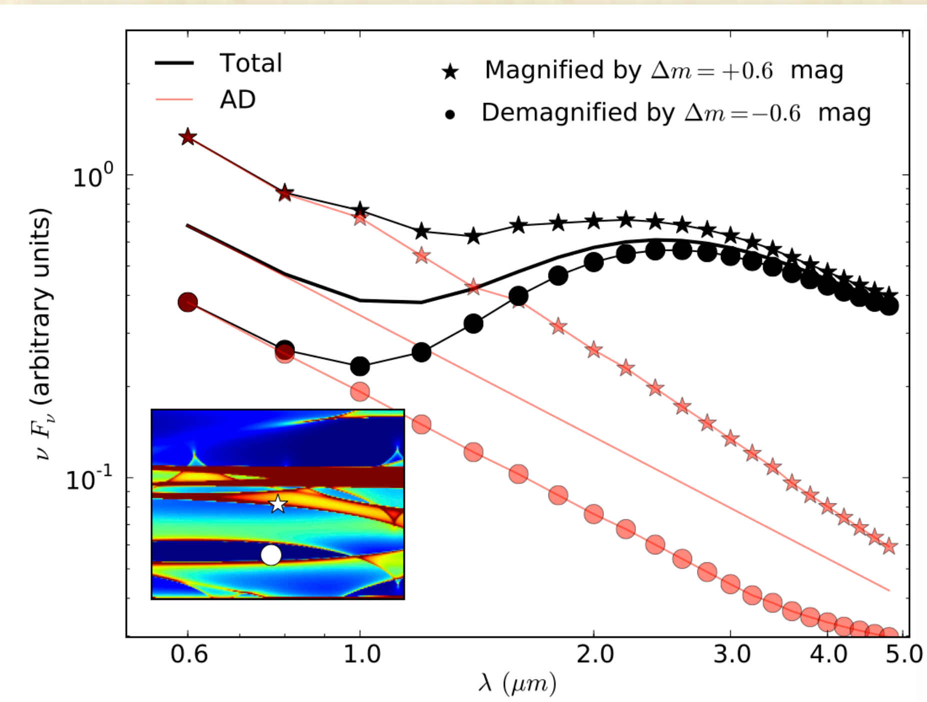


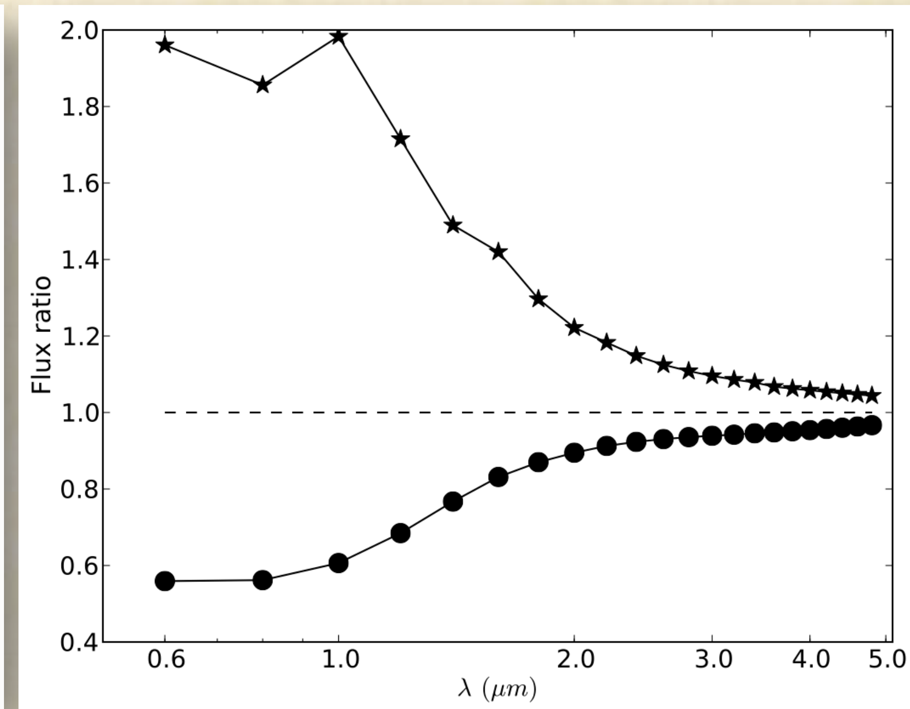
BLR not spherically symmetric
Differrences with ionization

Sluse+ 2011, A&A 528 A100; Sluse+2012, A&A, 544, A62

Torus

Because of its larger size, the torus is only weakly microlensed. Deformation of the SED are expected for large amplitude of microlensing (mix between AD and torus ML)





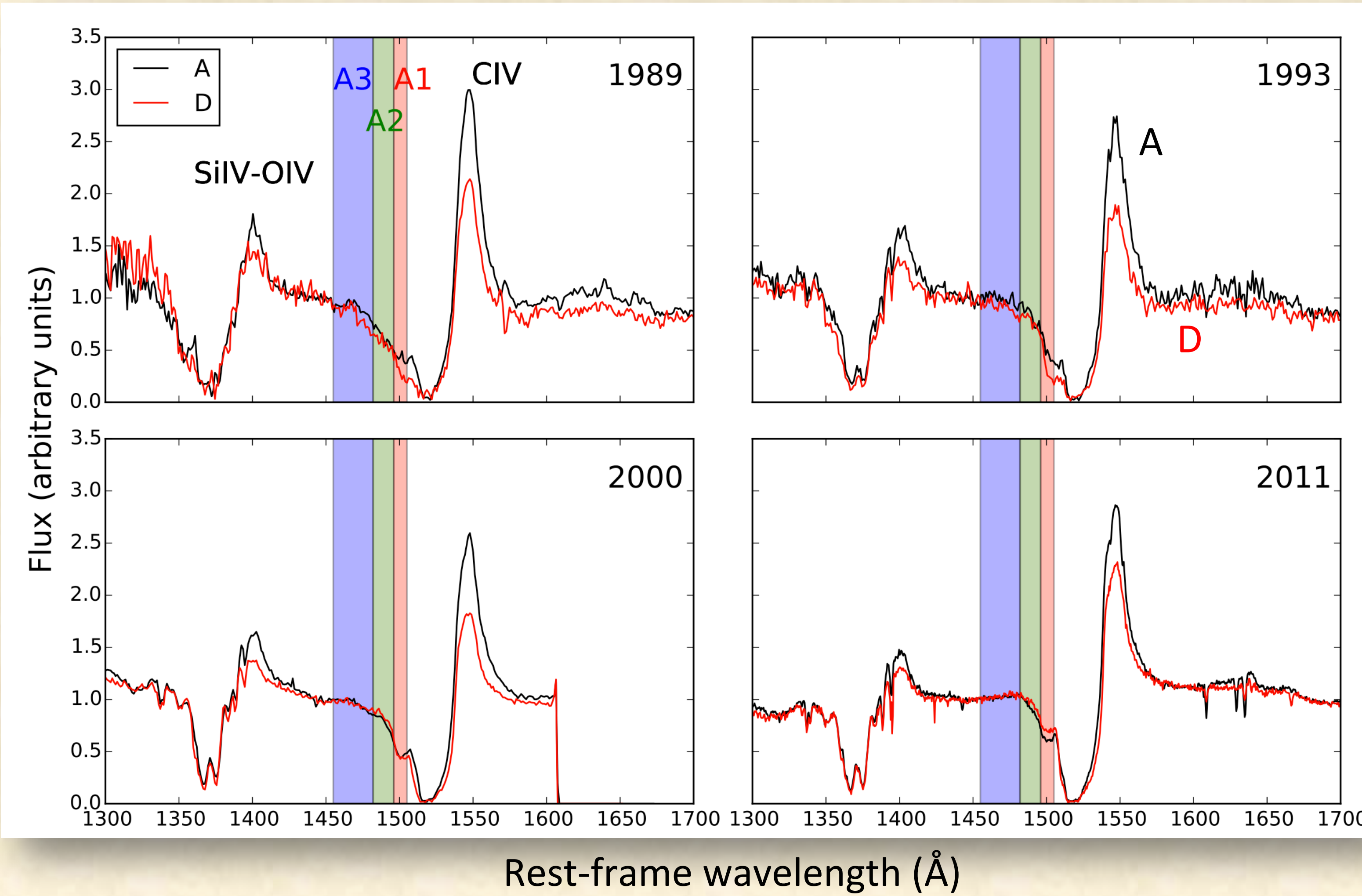
Absence of ML at 11.7 μm in Einstein cross ruled out synchrotron MIR emission (Agol+2000)

Sluse+ 2013, A&A, 553, A53

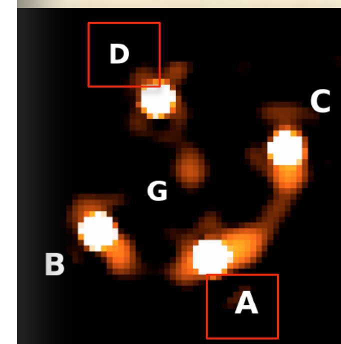
Conclusions

- AD sizes from ML are larger than theory (SS): Tension at the 1-2 σ level for individual works, but all over-estimate of the size.
- Evidence for extended/scattered continuum (30% of UV-continuum emission): may not solve ML-theory size discrepancies ... But it is there !
- Also ML constraints on AD orientation, AD temperature profile, BLR size, BLR geometry and identify differences in BLR structure between lines in a given object
- Still a lot to be done: pin-down uncertainties, need for data, manpower, combine ML with other techniques, independent analysis of existing data.

Accretion disk: Cloverleaf



H1413+117



z=2.55

Note that the flux of D is rescaled: D x M/μ

M = Macro magnification

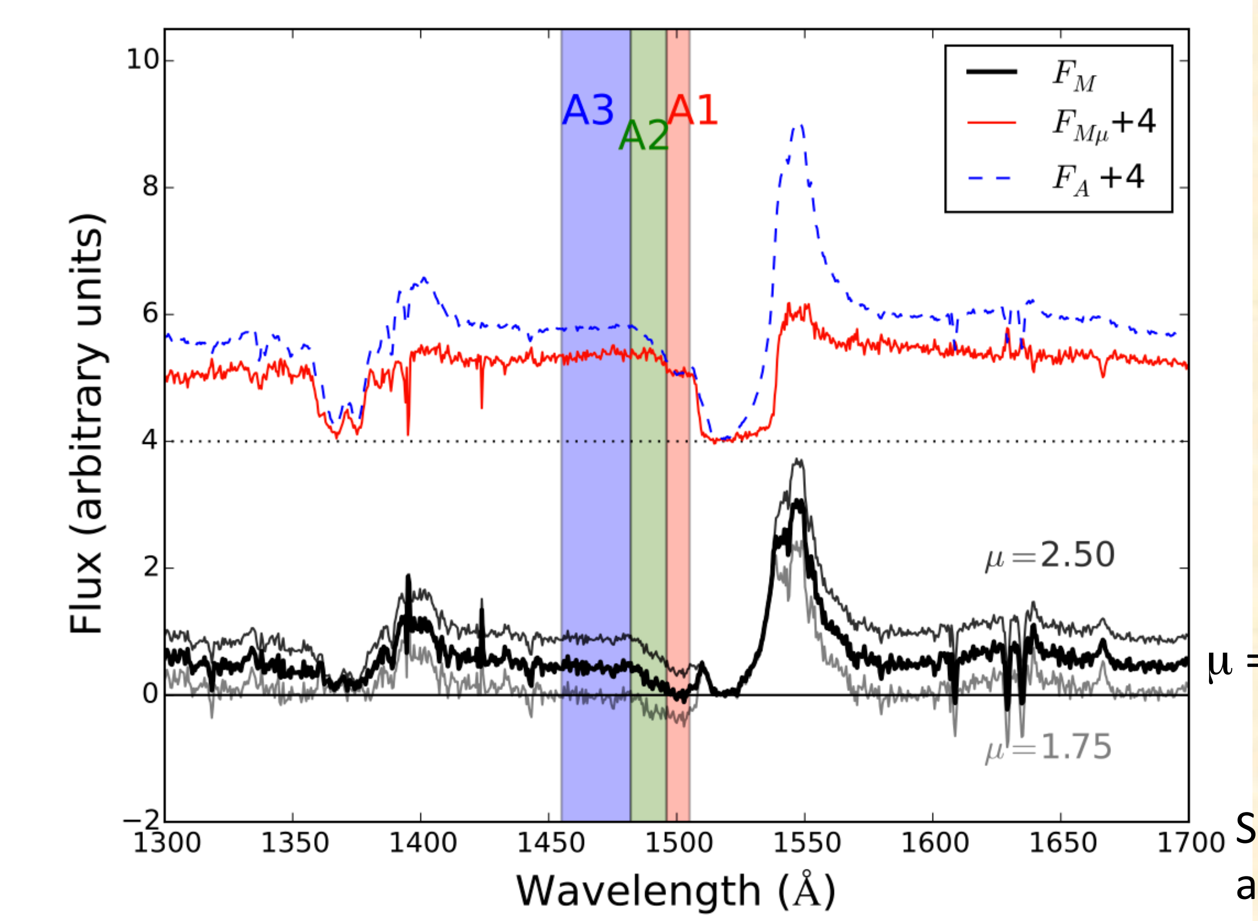
μ = micro magnification

Accretion disk: Cloverleaf

Using image A as a reference, and combining the spectra of A & D rescaled by M and μ, we can isolate:

F_M = fraction of flux unaffected by microlensing

$F_{M\mu}$ = fraction of flux affected by microlensing



μ = 2

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

Sluse et al. 2015
arXiv:1508.05394

Accretion disk: "Extended"

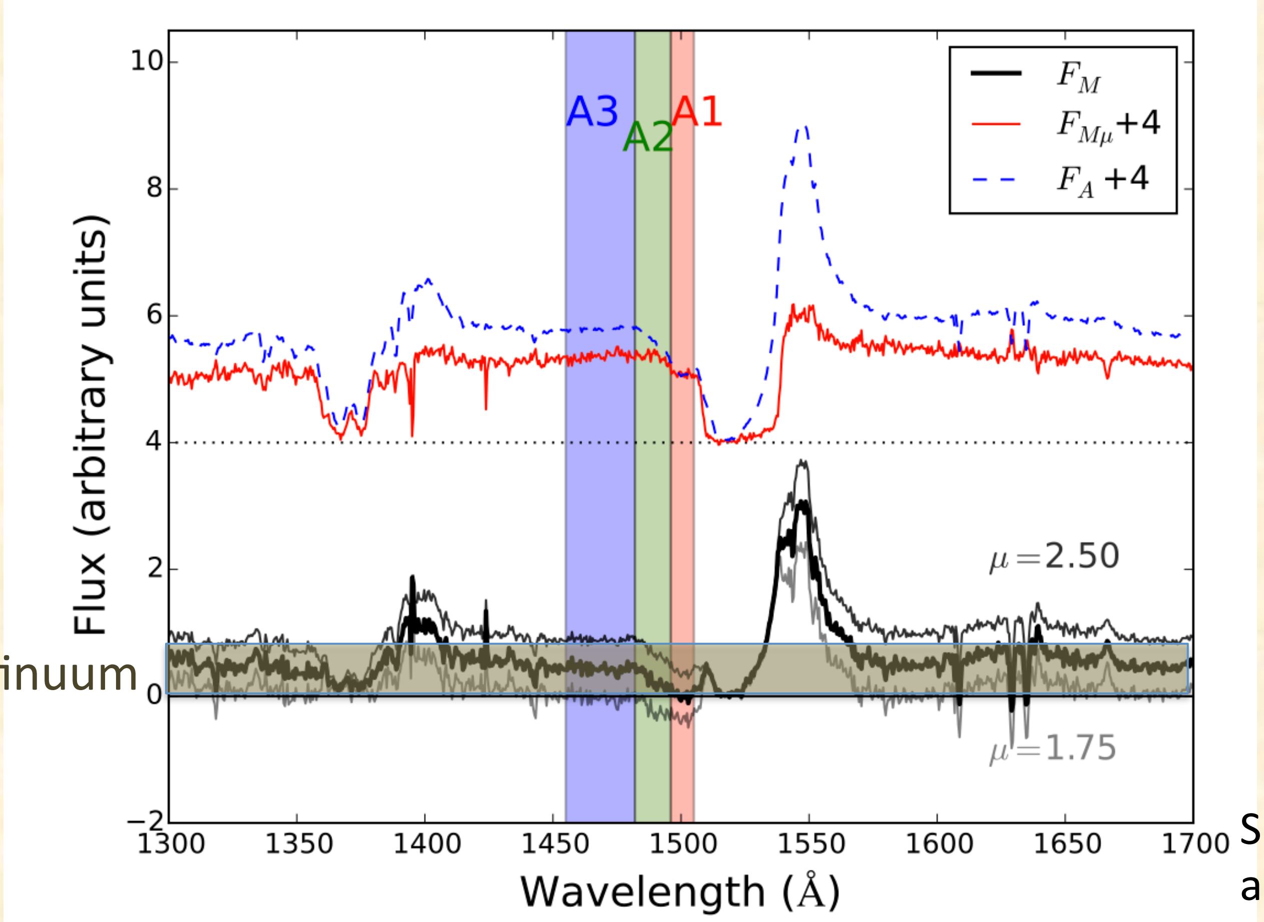
Using image A as a reference, and combining the spectra of A & D rescaled by M and μ, we can isolate:

F_M = fraction of flux unaffected by microlensing

$F_{M\mu}$ = fraction of flux affected by microlensing

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

Extended continuum



Sluse et al. 2015
arXiv:1508.05394