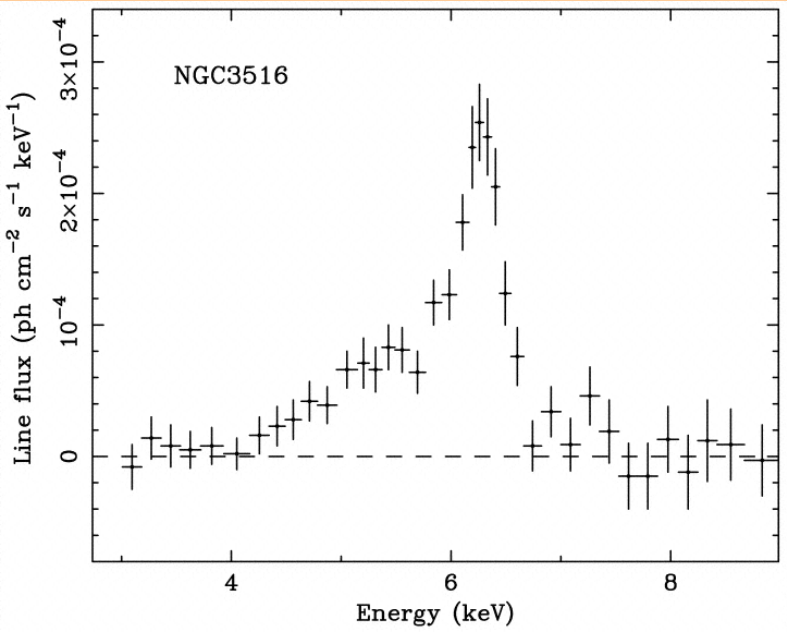
# Microlensing and Spectroscopy

Evencio Mediavilla & Jose A. Muñoz

# Broad Iron Lines (FeKα)




- **Nature of the accretion disc within a few gravitational radii ($GM/c^2$) of the BH**
- **BH spin (Kerr)**
- **A narrow FeKα component originating from matter far away from the central BH (e.g. A molecular torus) could also be present**

# Microlensing phenomenology

**NEL** → Unaffected by microlensing (define the baseline)

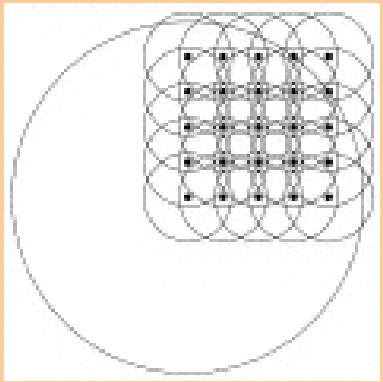
**BEL (LI/HI)** → Changes related to the ionization degree (potentially useful to study the unresolved structure of the BLR)

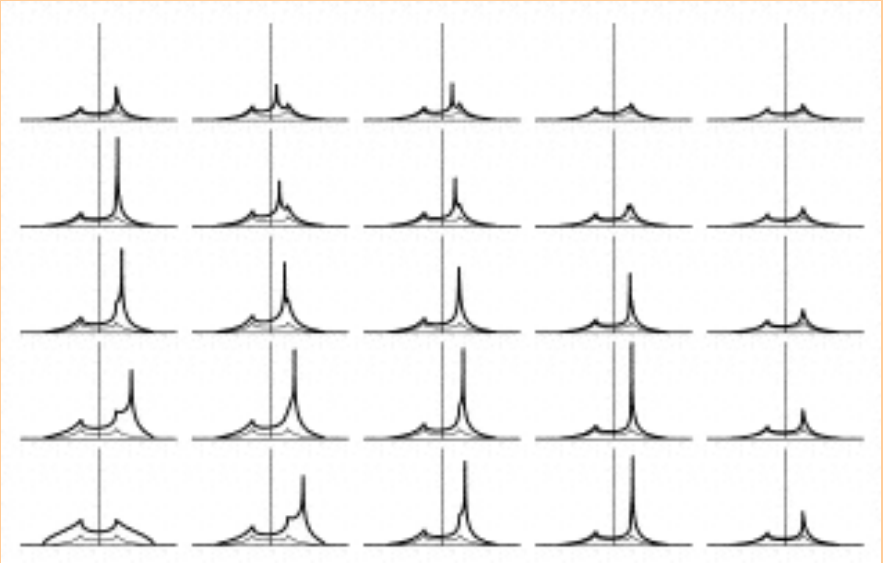
**FeKα** → Strong and fast variability is expected (potentially useful to study the inner region of the acrettion disk where exotic physics is expected)

**Continuum** → Variability (studied with image photometry) + Chromaticity (useful to study the structure of the continuum source)

# Influence of microlensing in the emission line shapes

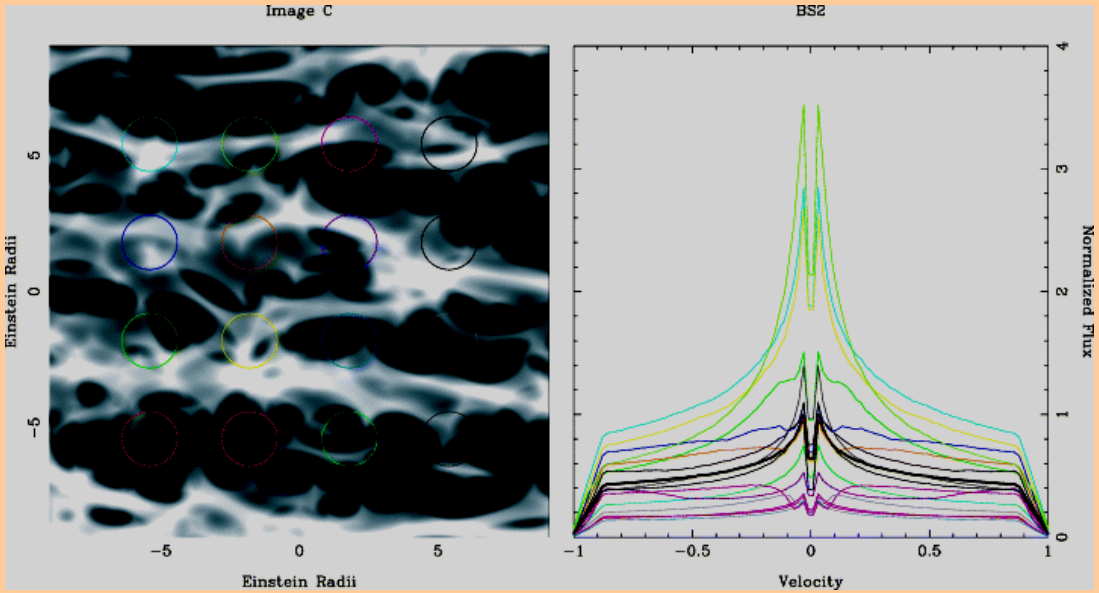
**Early studies by Nemiroff (1988) and Schneider & Wambsganss (1990) based in a large BLR (0.1-1 pc) predict only fractional deformations**



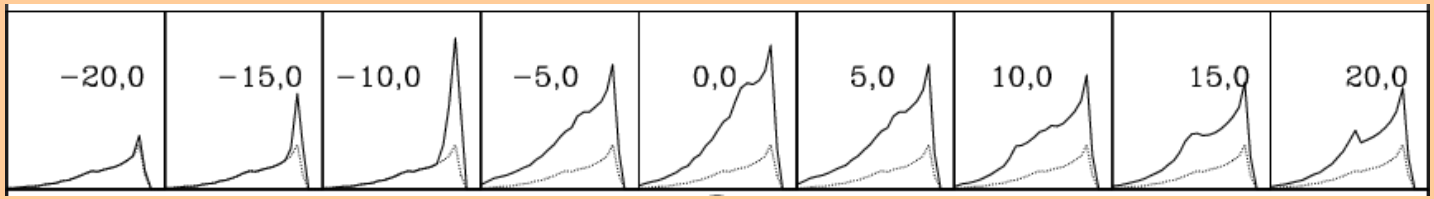


**Abajas et al. 2002**

# Influence of microlensing in the emission line shapes




**Lewis & Ibata 2004**



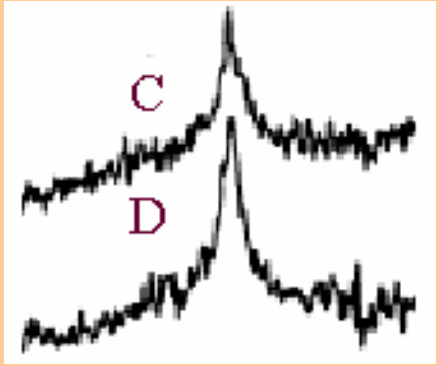

**Popovic et al. 2003**

# Observations

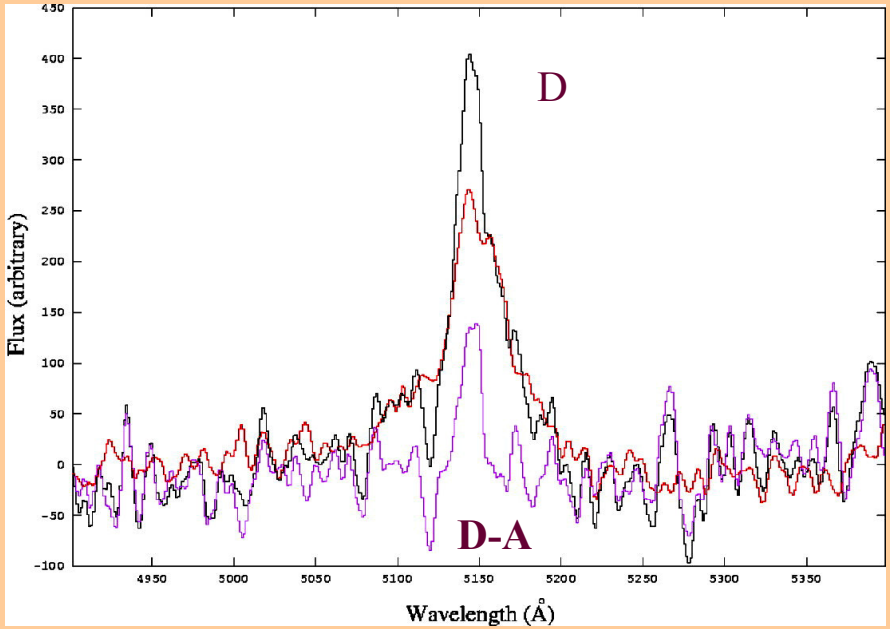
- Q 2237
- Q 0957
- HE 1104
- SBS 0909
- HE 0512
- HE 1413
- J 1004

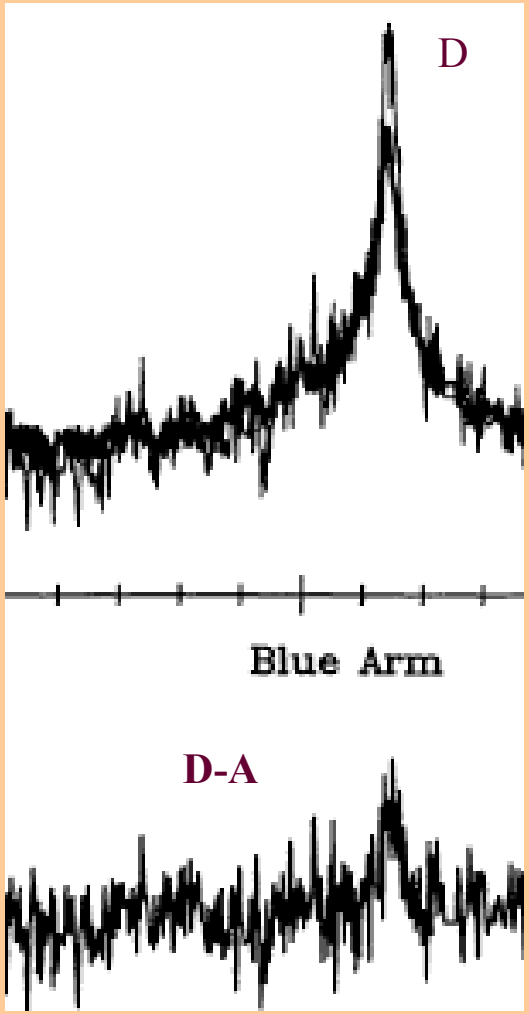
# QSO 2237+0305 AB / CIII]λ1909

**Adams et al. 1988**



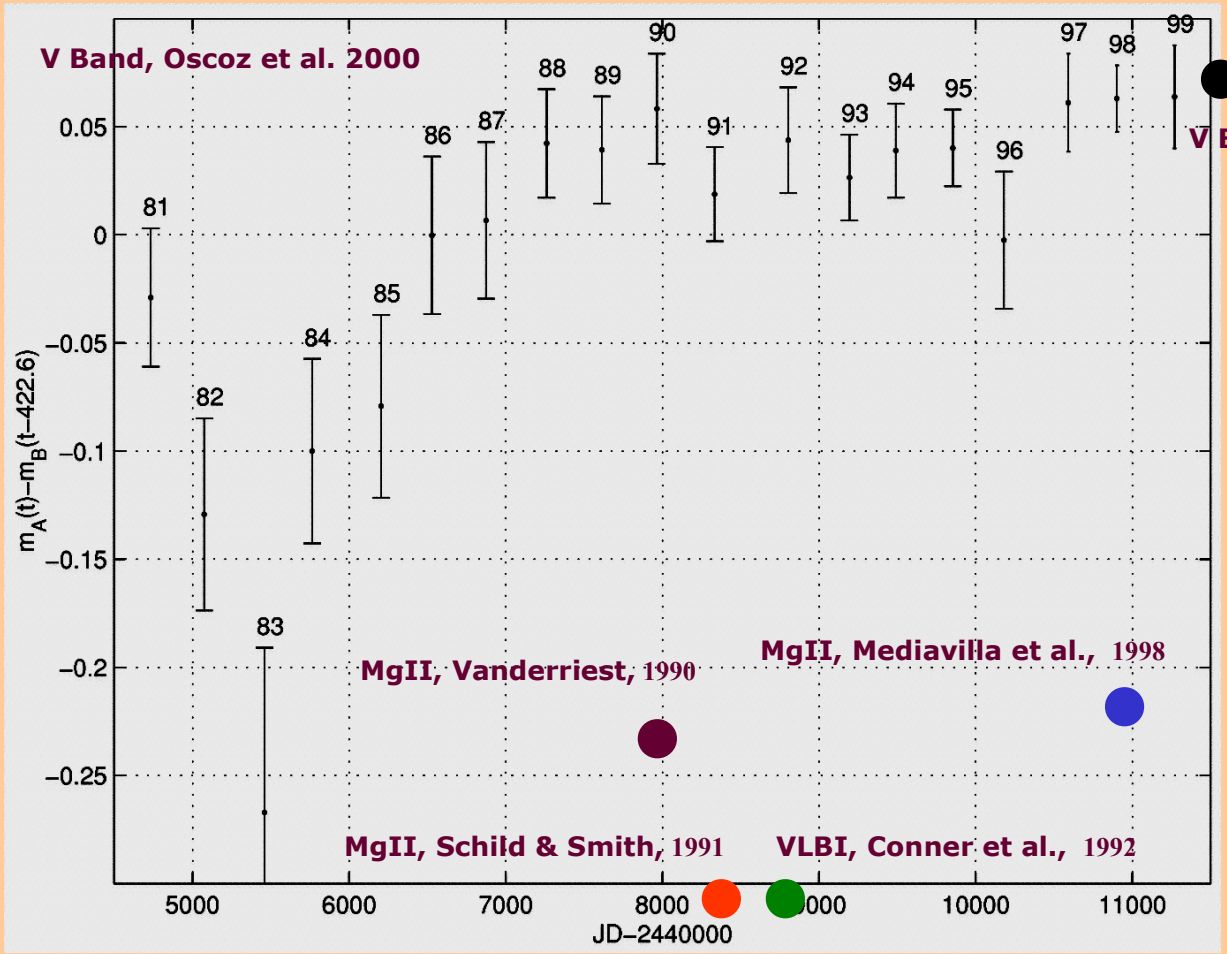

**Mediavilla et al. 1998**




**Lewis et al. 1998**

# QSO 0957+561


V Band, Oscoz et al. 2000
V Band, Goicoechea et al. 2000
MgII, Vanderriest, 1990
MgII, Mediavilla et al., 1998
MgII, Schild & Smith, 1991
VLBI, Conner et al., 1992
81
82
83
84
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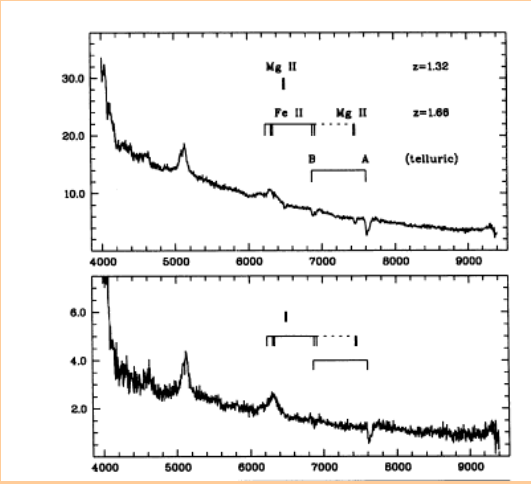
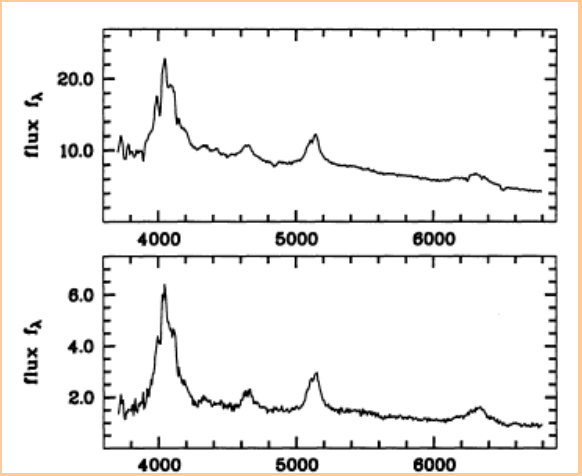
88
89
90
91
92
93
94
95
96
97
98
99
0.05
0
−0.05
−0.1
−0.15
−0.2
−0.25
5000
6000
7000
8000
10000
11000
JD−2440000
$m_A(t)-m_B(t-422.6)$

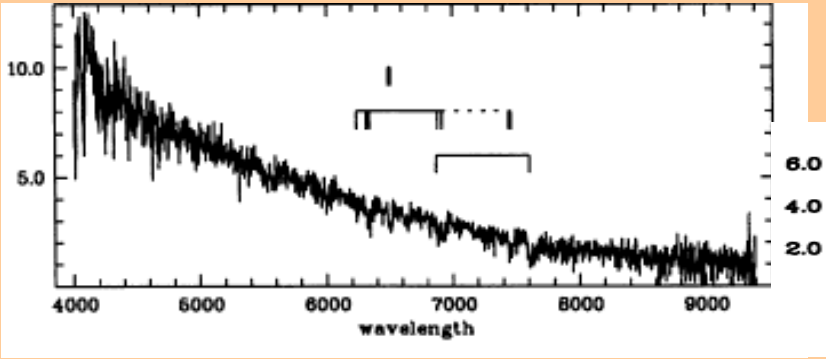
# HE 1104 -1805

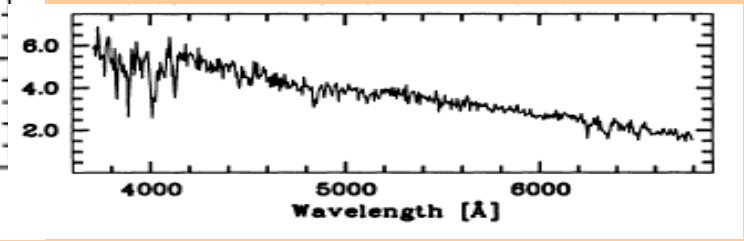
## Wisotzki et al. 1993



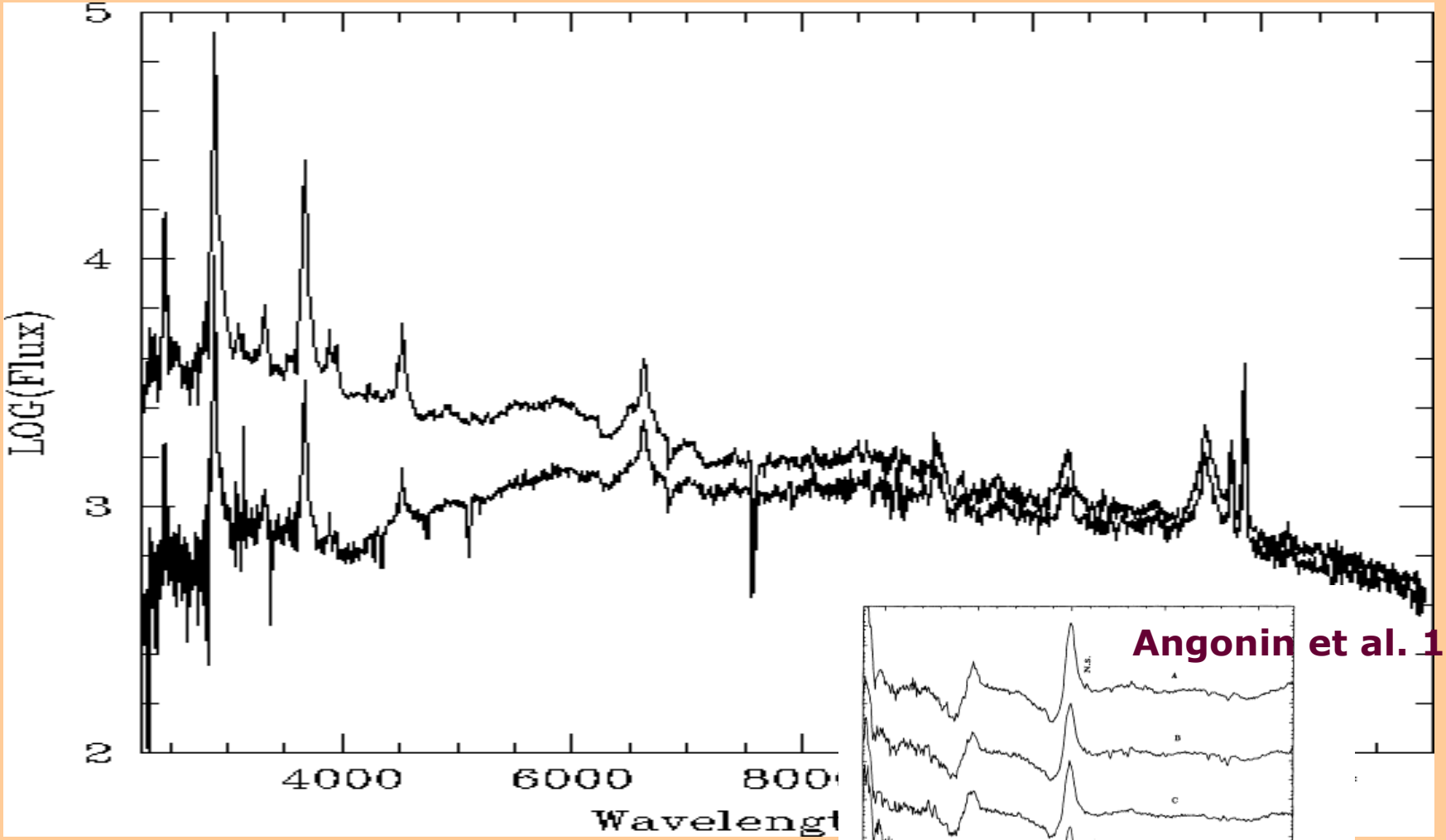

## Wisotzki et al. 1995



# QSO spectra (SBS 0909+531)







Angonin et al. 1990

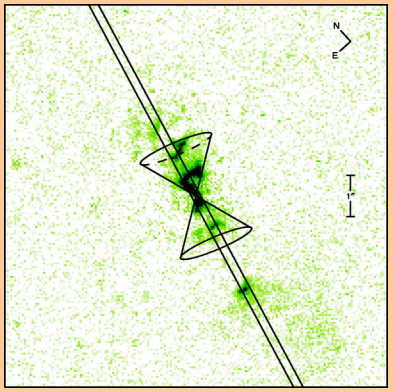
# NLR/ENLR

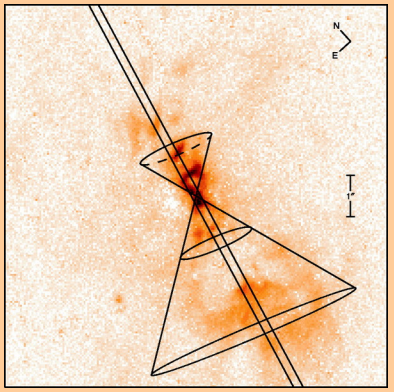
- Extended at galaxy scale

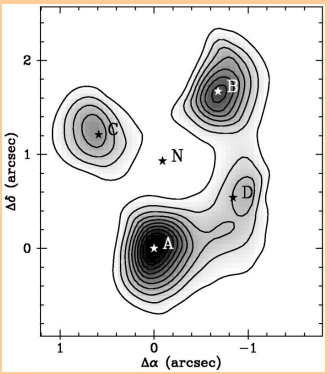
  **(not affected by microlensing)**

- Could be imaged in arcs

  **(may not be useful to compute the intrinsic magnification ratios)**



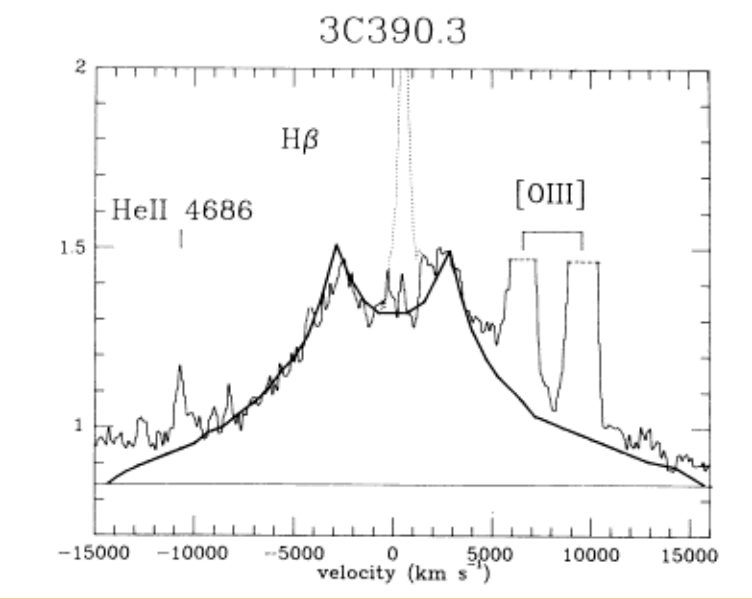




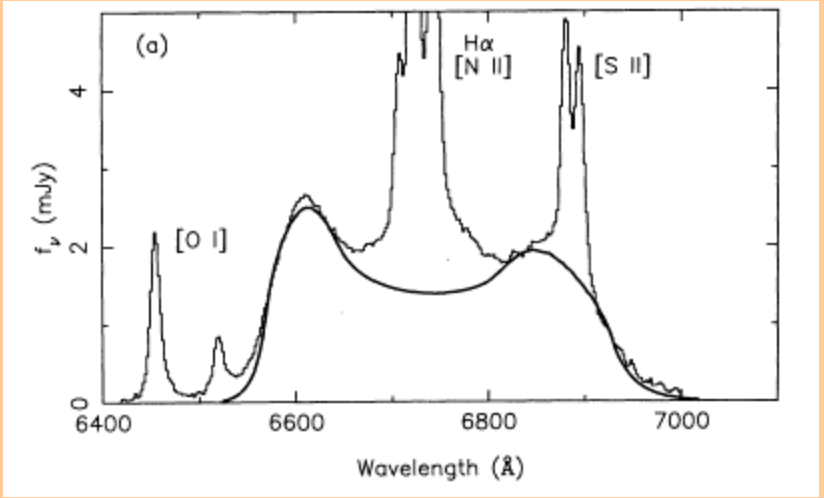

**Q 2237+0305**
**Mediavilla et al 1998**

# BLR: Accretion disk + ...

**Perez et al. 1988**

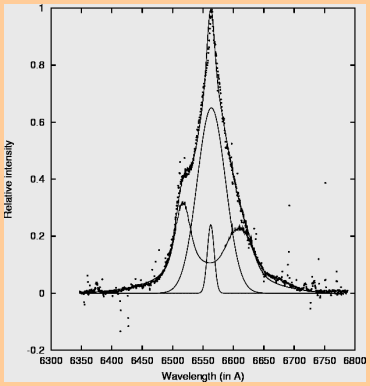


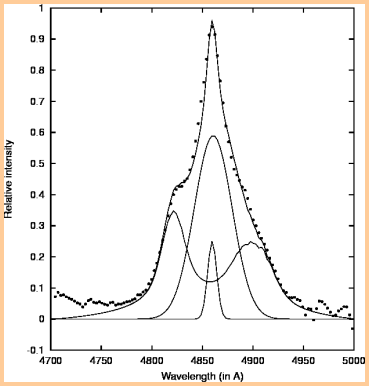

**Chen et al. 1989**

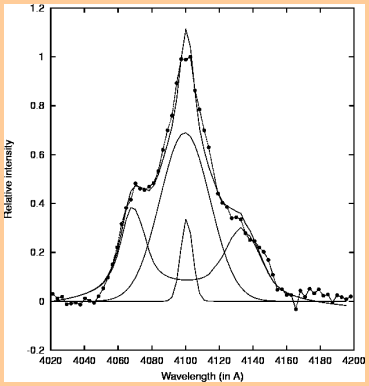


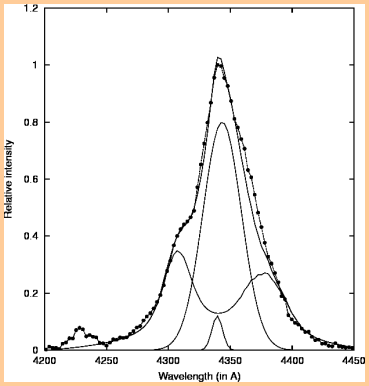

**Two peaked features that can be fitted by an accretion disc model**

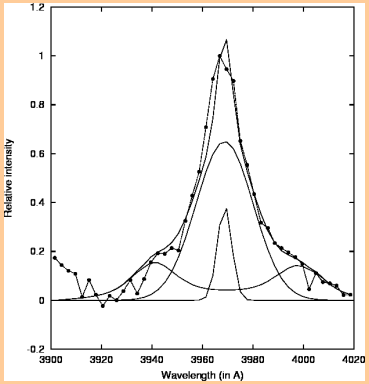
# BLR: Accretion disk + Outer component

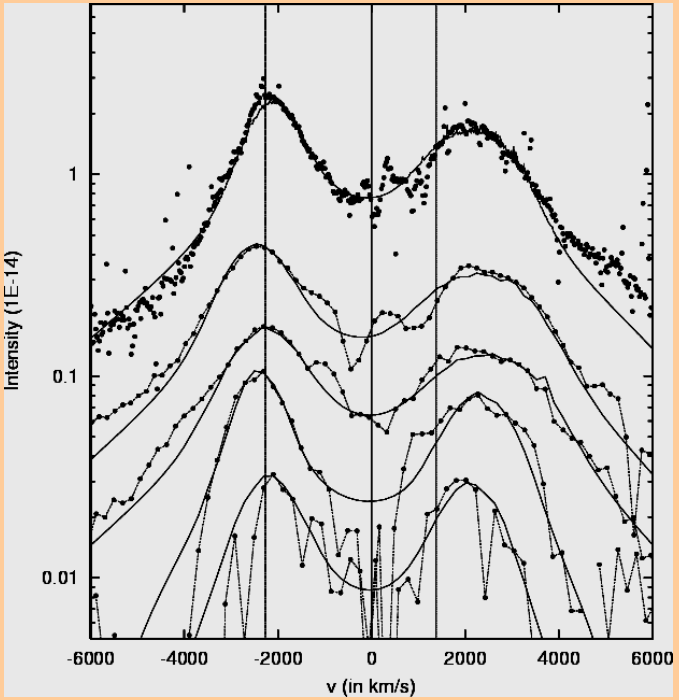


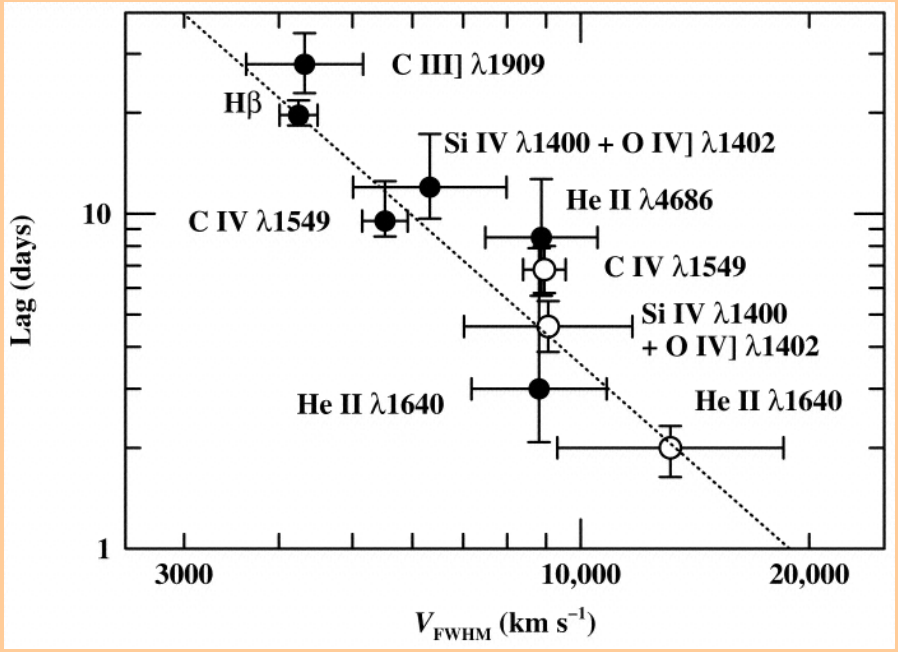



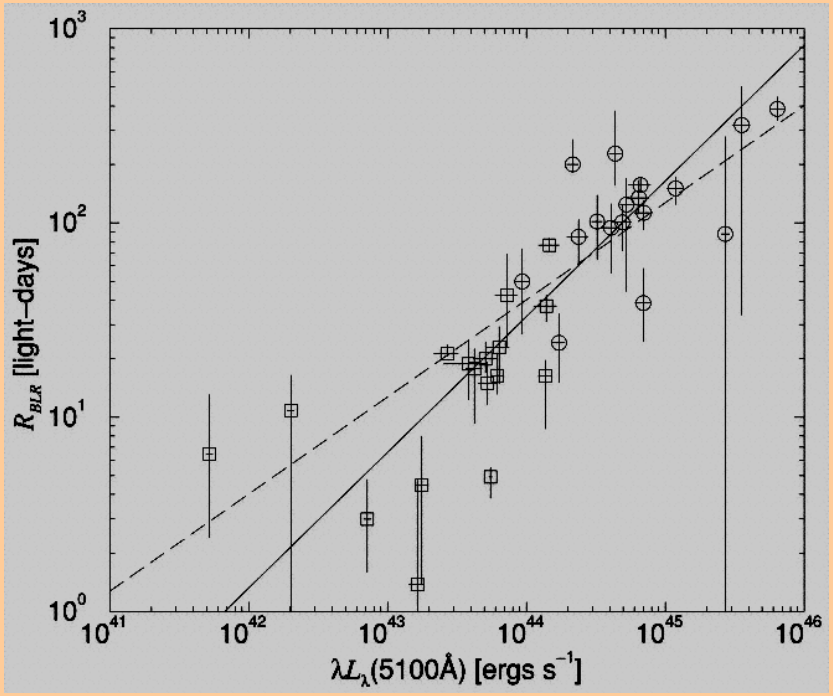

**NGC 3516, Popovic et al. 2002**

# BLR stratification and luminosity/size dependence

**NGC 5548, Peterson & Wandel 1999**



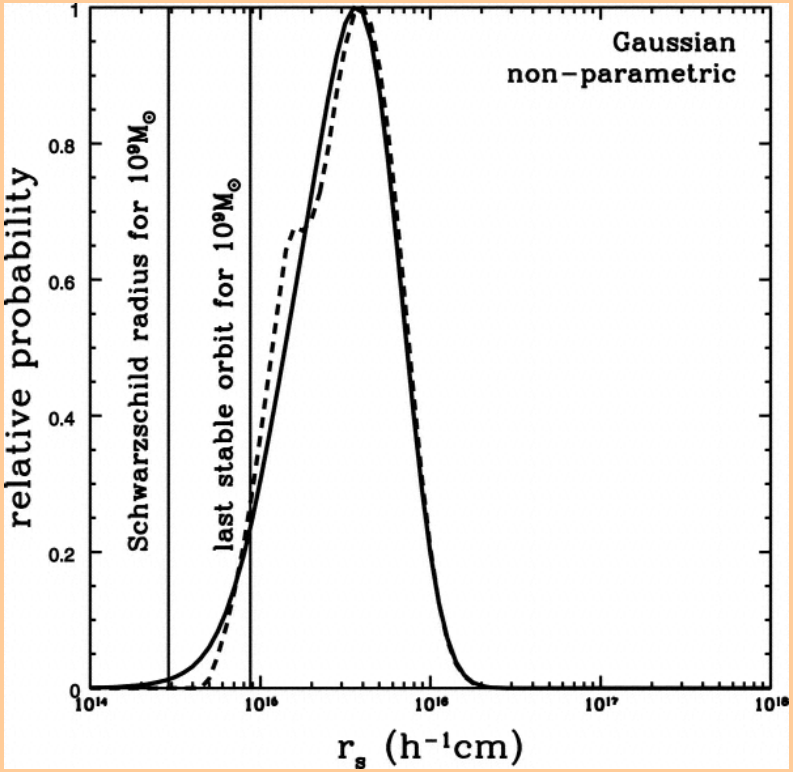

**Kaspi et al. 2000**



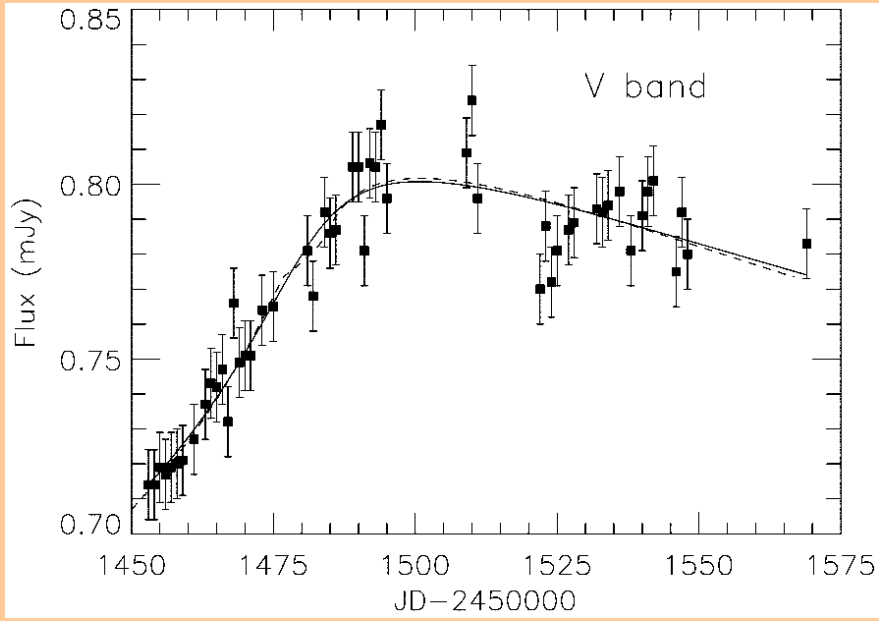

**Microlensing is more likely to be detected in HIL of low luminosity active nuclei**

# Continuum

**Kochanek 2004**



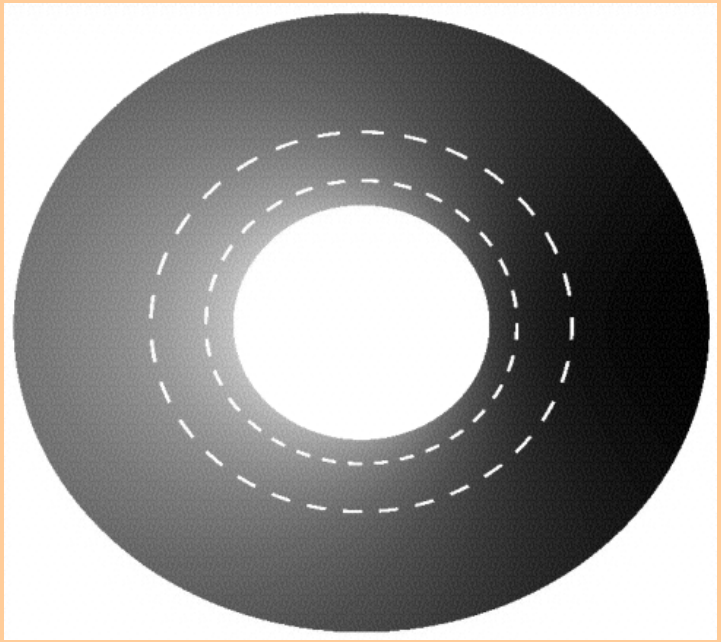

**Shalyapin et al. 2002**

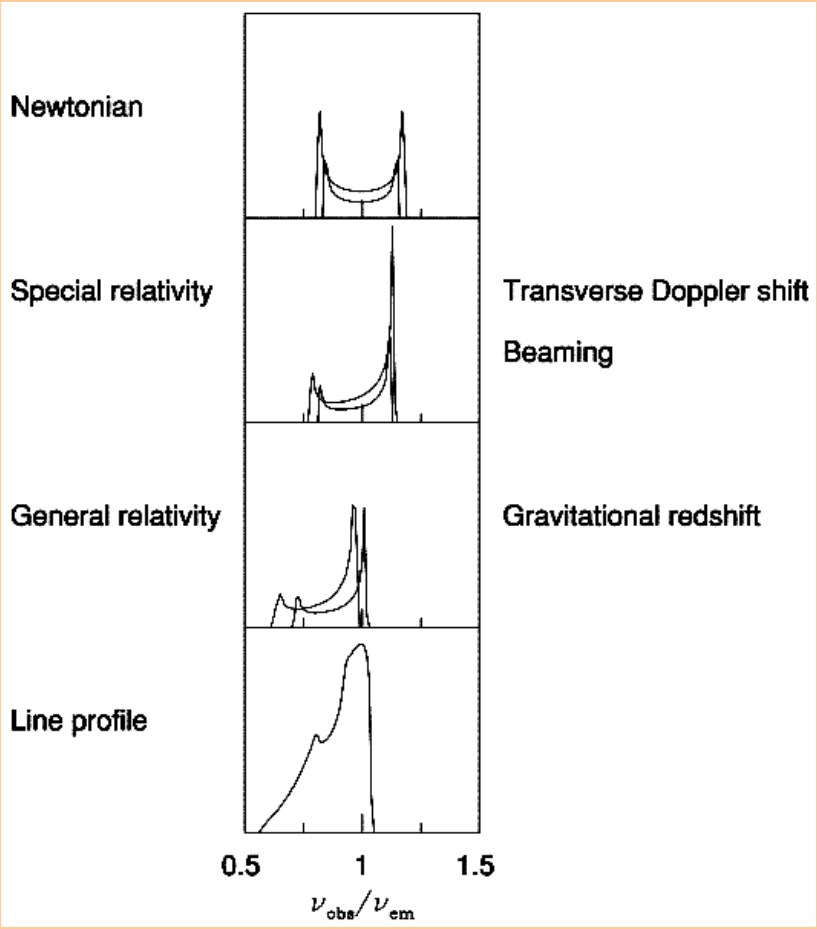



**Generated by a inner accretion disc in the standard model for AGN**

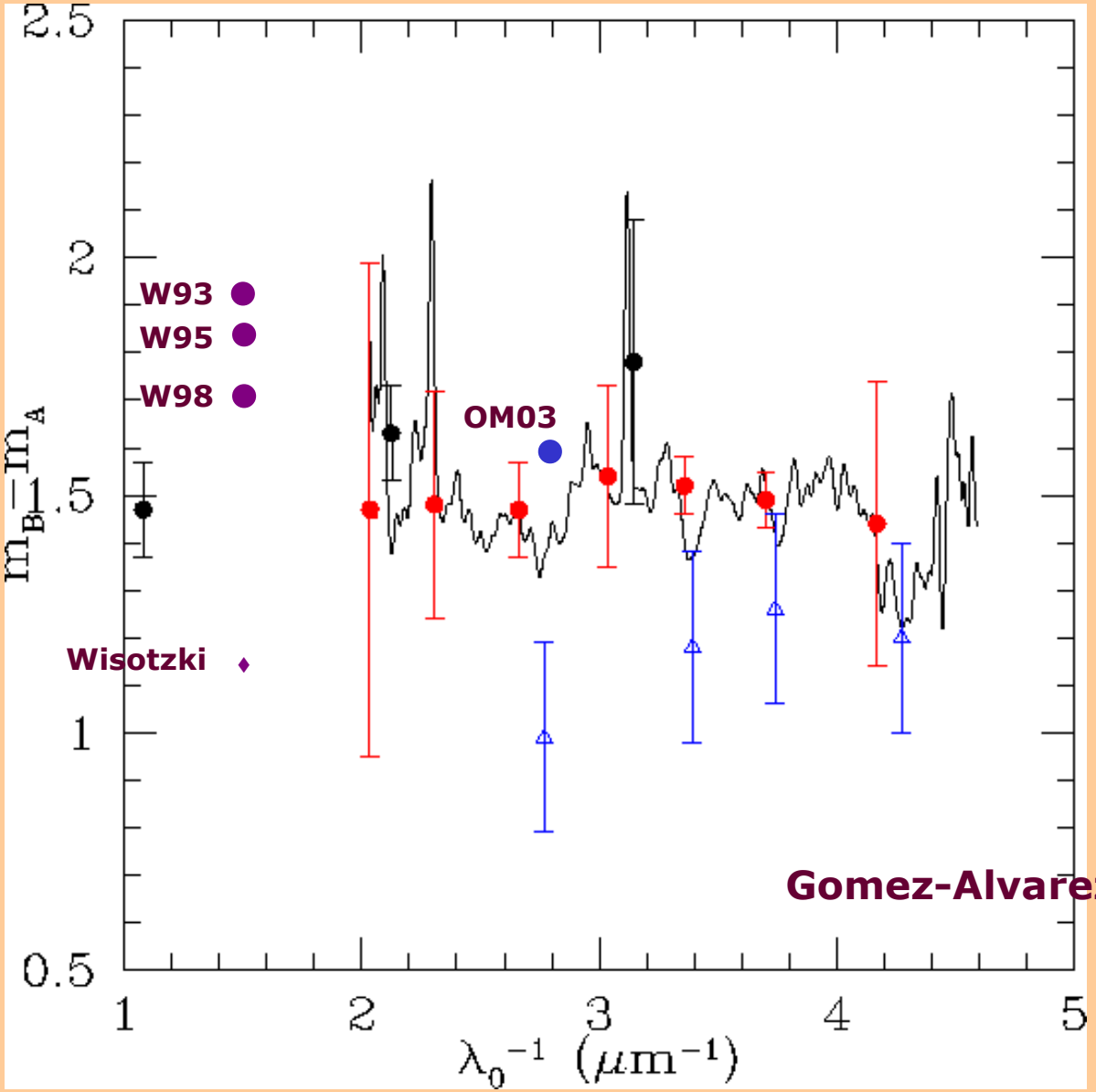
# Broad Iron Lines (FeKα)

**Fabian 2000**





# HE 1104 -1805

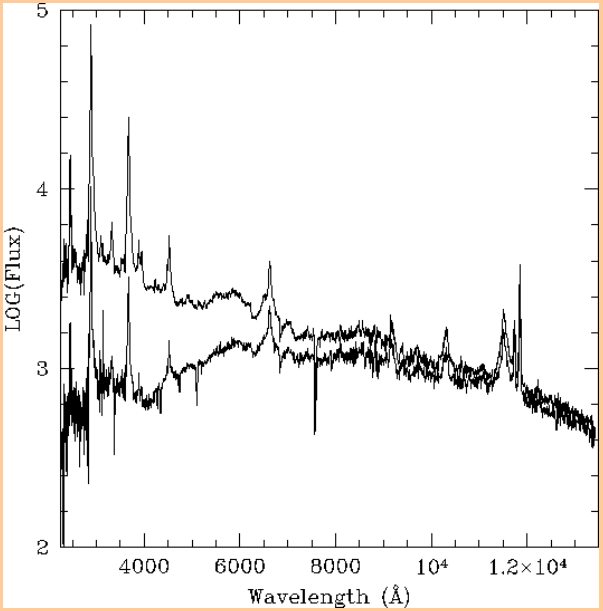


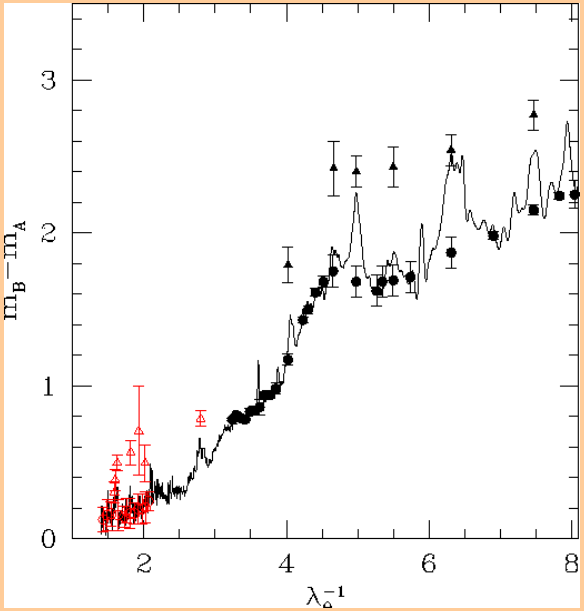

Gomez-Alvarez et al. 2004

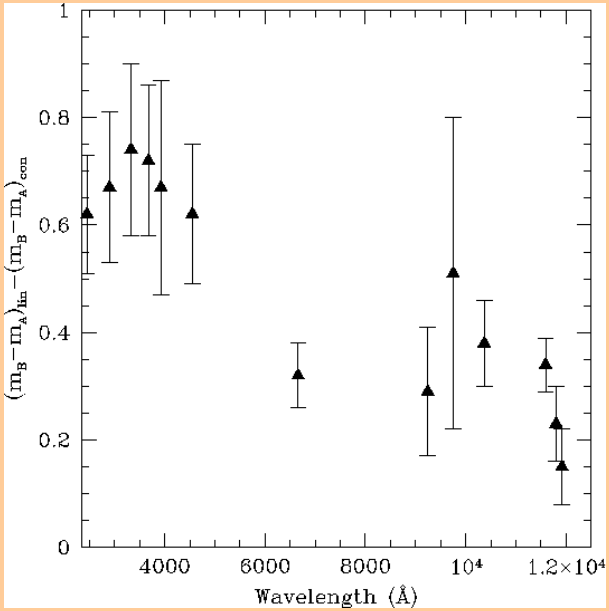
# HE 1104 -1805 (10 years summary)

- **Spectrophotometry shows microlensing continuum variability of $\Delta(m_B-m_A)=0.4$ mag in 10 years**
- **In good agreement with the slope of microlensing variability of 0.043 mag/year found from R and V photometry from 5 years monitoring**
- **No variability detected in the emission lines: $(m_B-m_A)_{lines}=1.58$ mag**
- **Chromaticity decreases and disappears**
- **Are we observing a microlensing induced two-dimensional scanning over the active nucleus? 🕓 In the next 10 years the continuum microlensing event should finish**

# SBS 0909+531



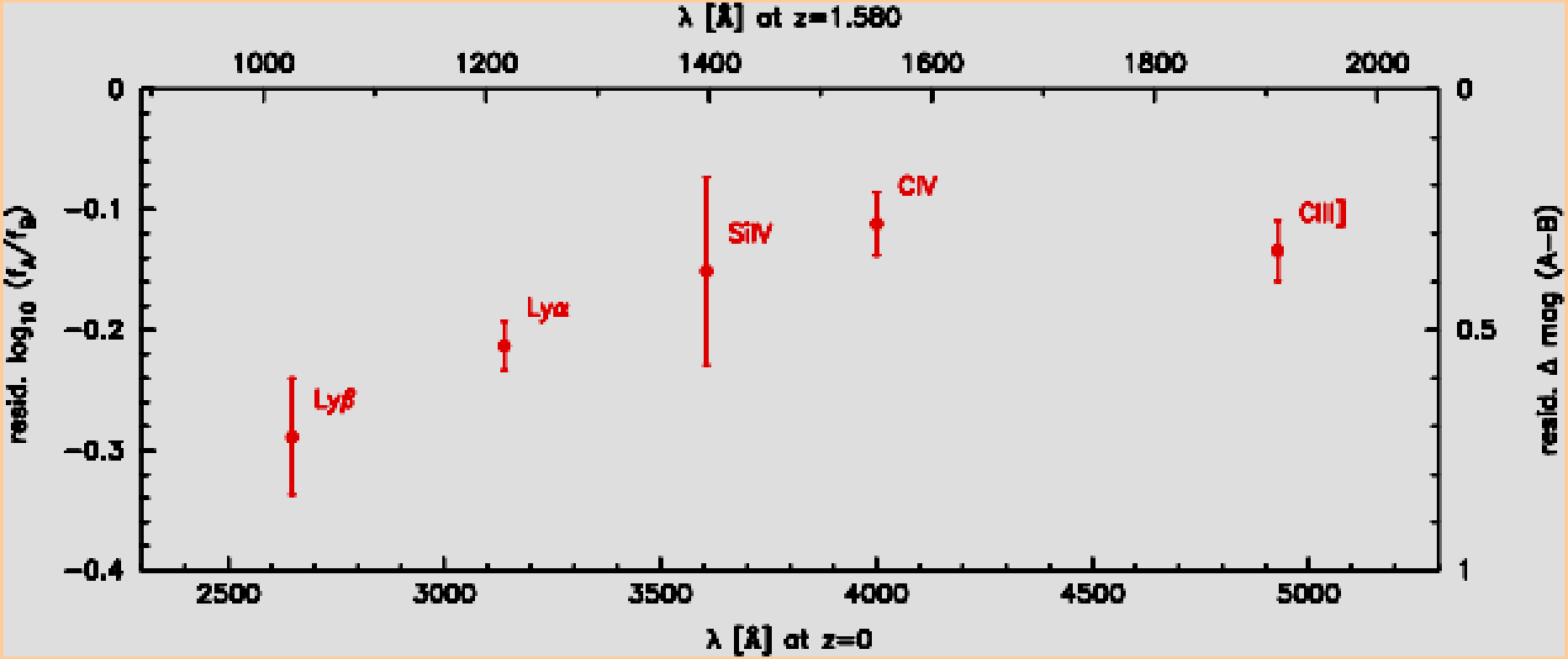




**Motta et al. 2002**
**Mediavilla et al. 2004, 2005**

# HE 0512-3329

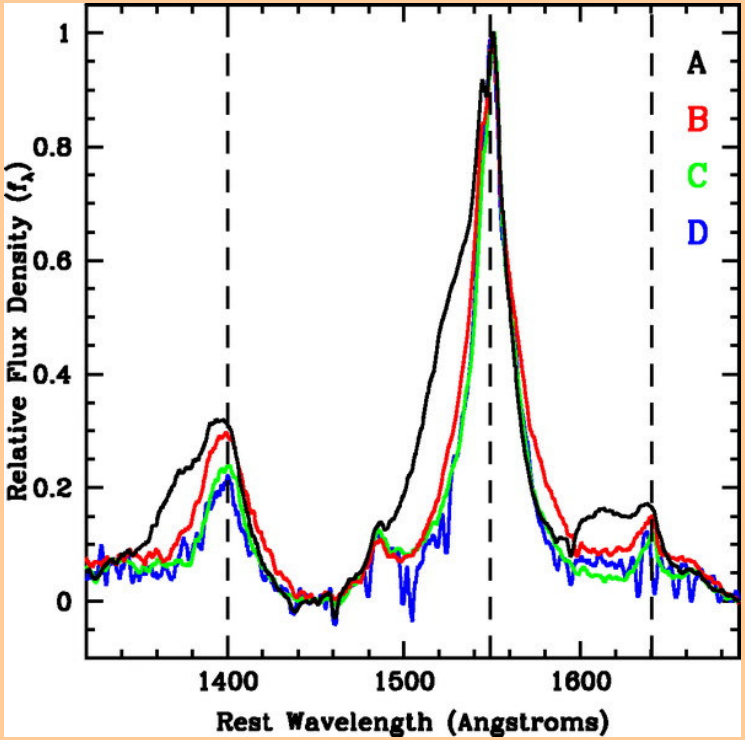
**Wucknitz et al. 2003**

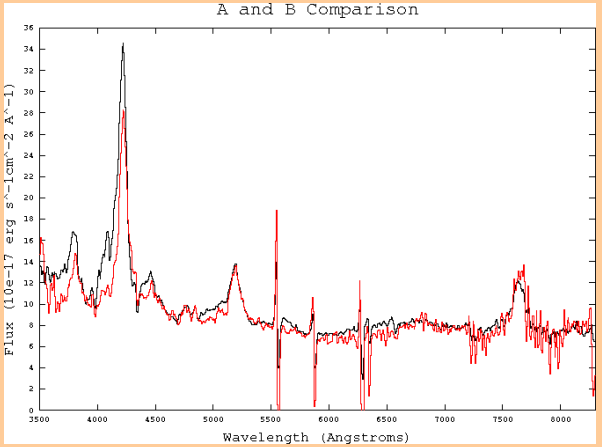


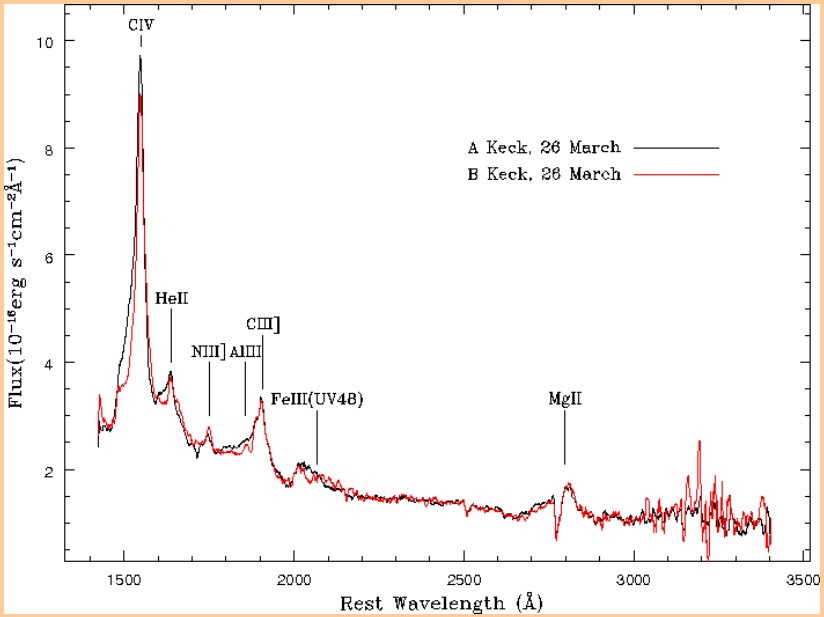
# J 1004

## Gomez-Alvarez et al. 2004

## Richards et al. 2003

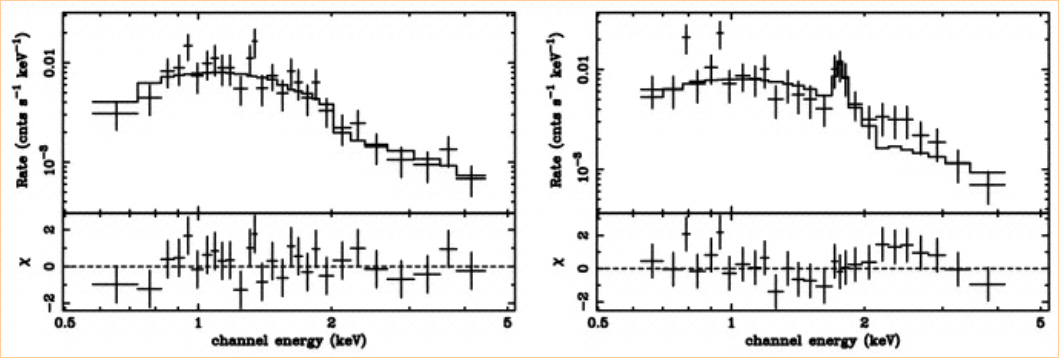


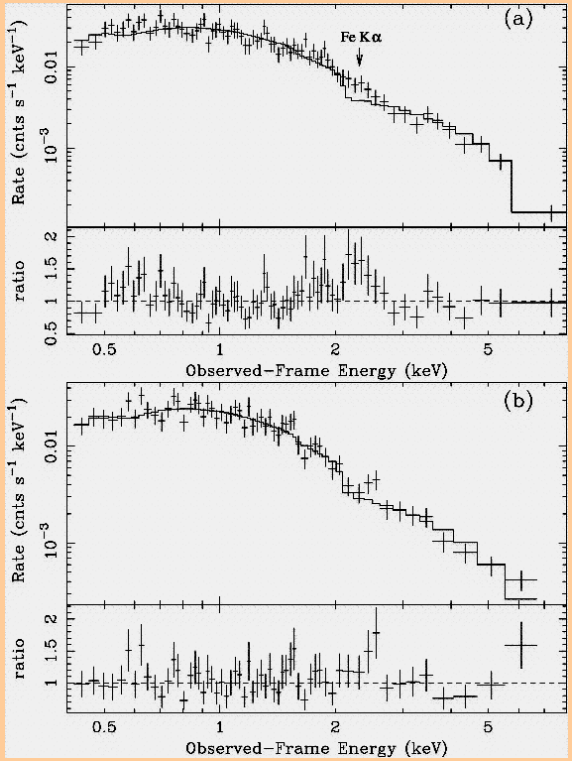




## Richards et al. 2004

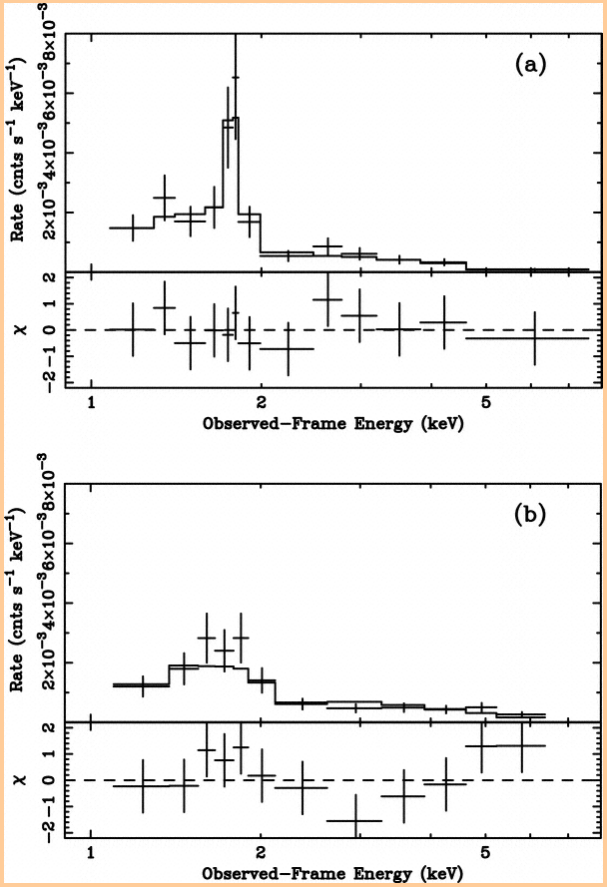
# FeKα




**J0414+0534B,**
**Chartas et al. 2002**




**H1413+117A,**
**Oshima et al. 2001**
**Chartas et al. 2004**




**Q 2237+0305A,**
**Dai et al. 2003**

# Summary

- **The presence of different magnification ratios in the emission lines with respect to the continuum ones seems to be more the rule than the exception.**

- **Wavelength dependence of microlensing (chromaticity) in the continuum is detected using the emission lines as baseline in Q 0909 and Q 0512. Monitoring of the chromaticity variability (HE 1104?) would allow to map the unresolved continuum source.**

- **Variability has been observed in the high ionization emission lines of J 1004 (BLR mapping…). However the interpretation is not clear.**

- **There is also evidence of variability in the FeK lines of H 1413+117, Q 2237+0305, J0414+0534 (this could open the study of "exotic physics"). However it should be explained (aswell in the case of 1004) why this variability is not related to any continuum change.**