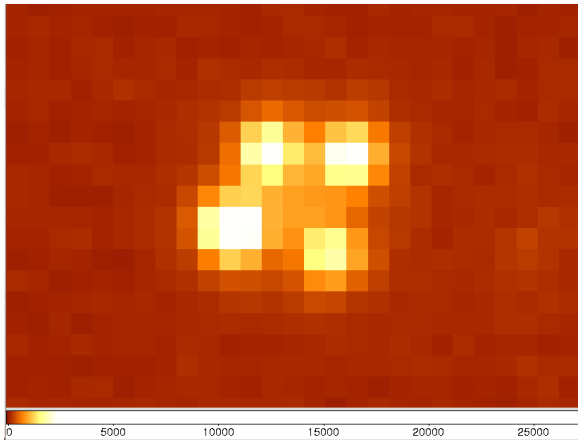
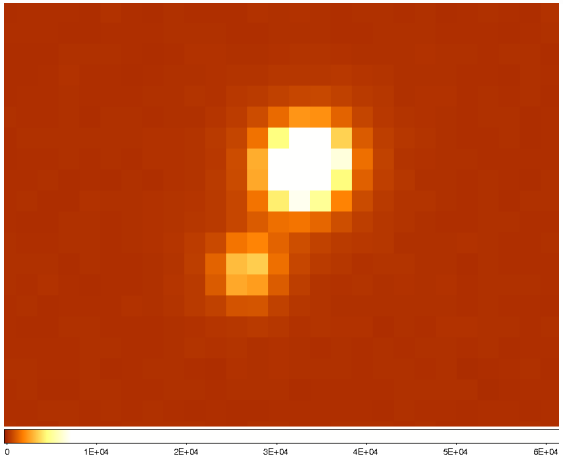
Flux and color variations of the multiply imaged quasars HE0435 and UM673

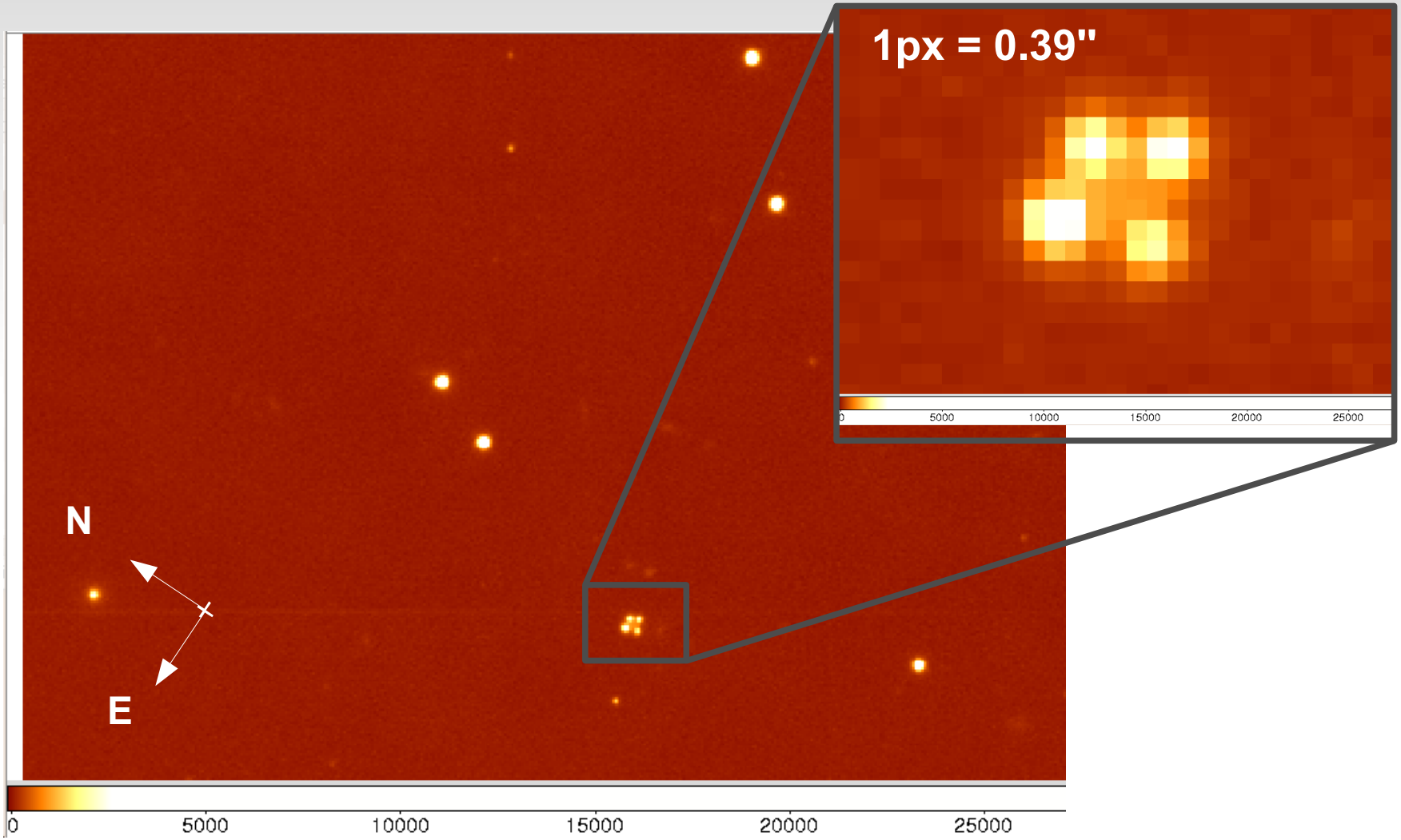
HE0435



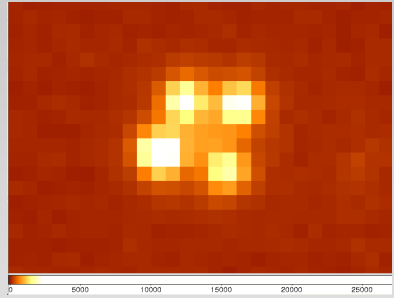
UM673



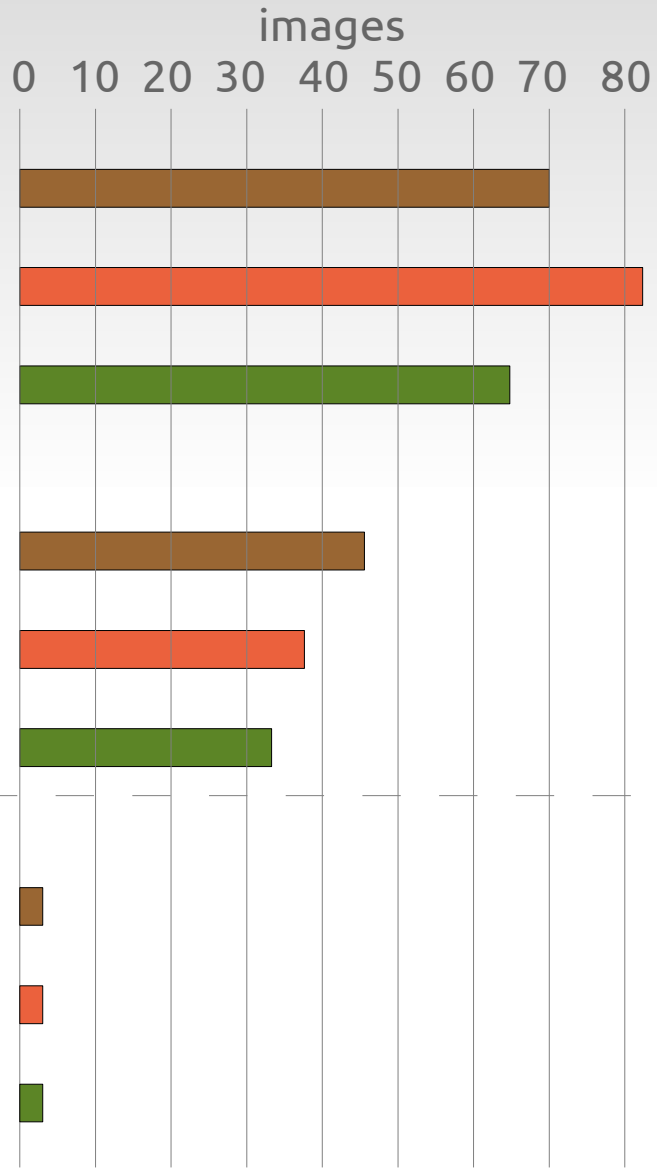
HE0435

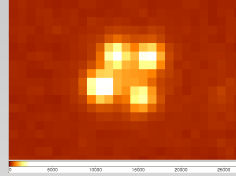


HE0435 data



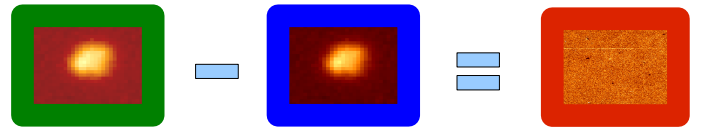
- 216 images in 2008
  - 70 in Gunn i (26 nights)
  - 83 in Bessel R (32 nights)
  - 63 in Bessel V (25 nights)
- 116 images in 2009
  - 46 in Gunn i (17 nights)
  - 37 in Bessel R (14 nights)
  - 33 in Bessel V (12 nights)
- 47 images in 2010
  - 14 in Gunn i (5 nights)
  - 18 in Bessel R (6 nights)
  - 15 in Bessel V (5 nights)

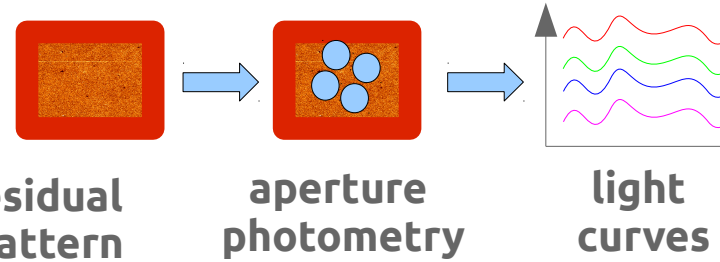




HE0435 reduction techniques

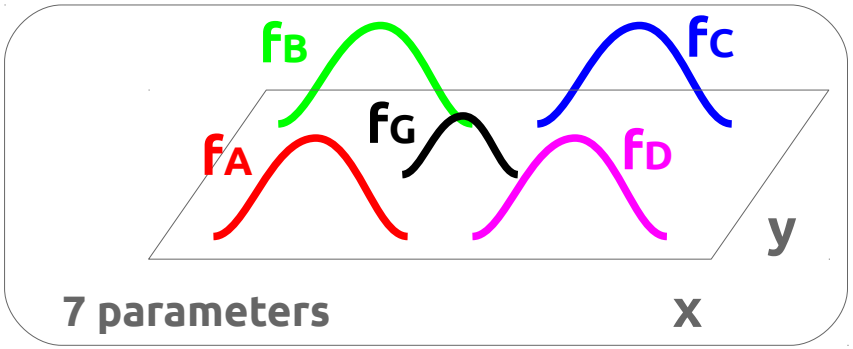
Difference imaging (Joël Poels)

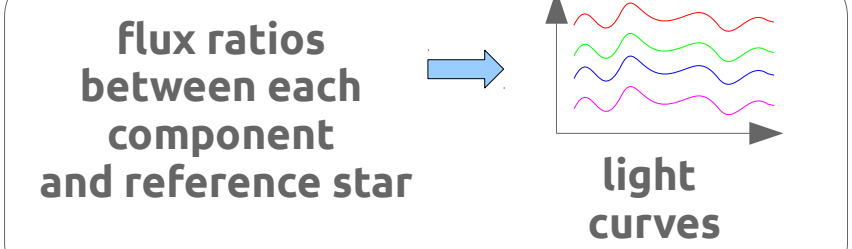


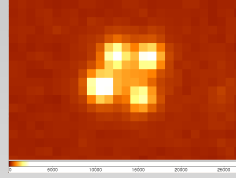


PSF fitting (Andrii Elyiv)

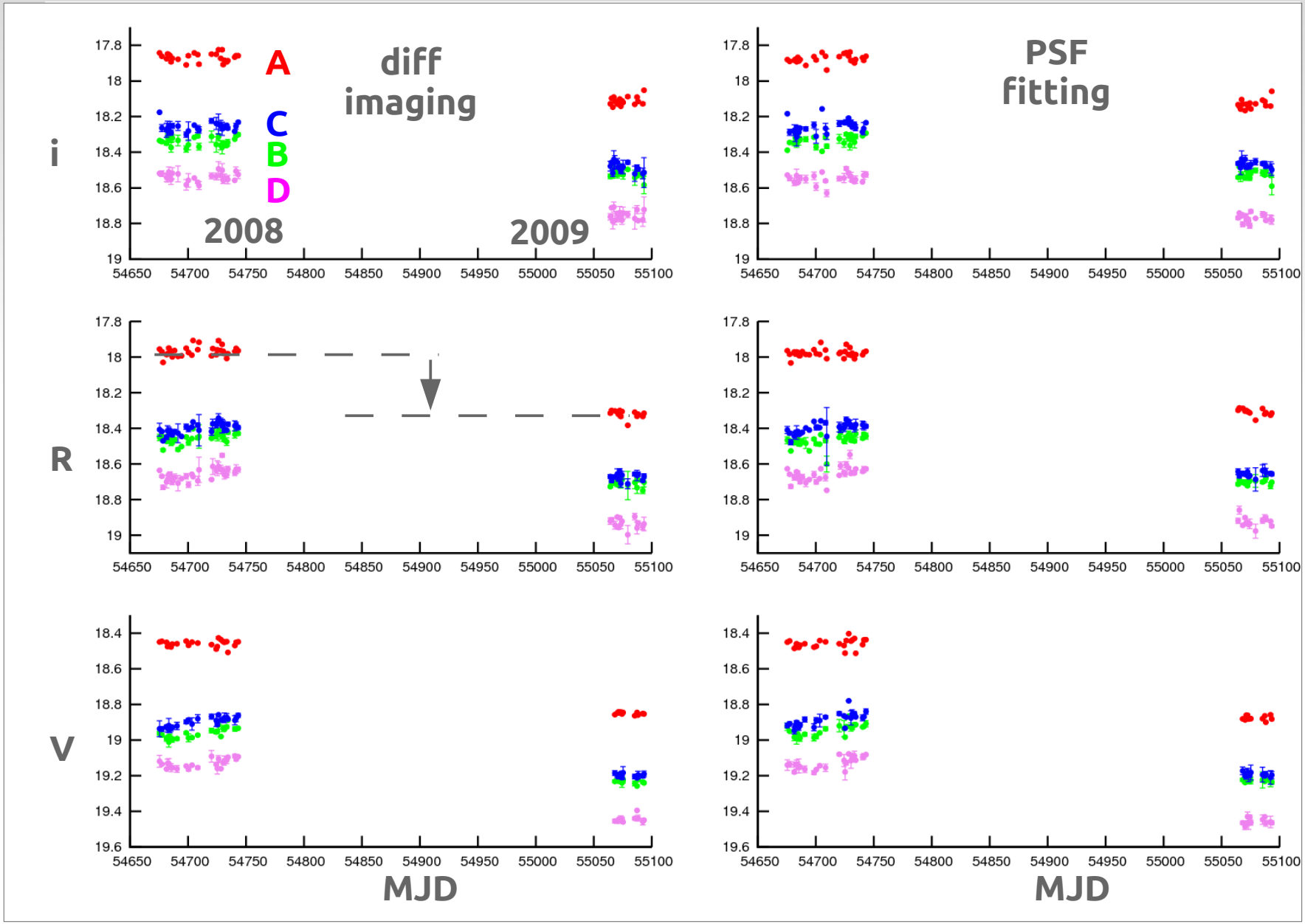
- Choosing a reference star
- Fitting 5 PSF
- coordinates from Kochanek (2006)
- 7 free parameters



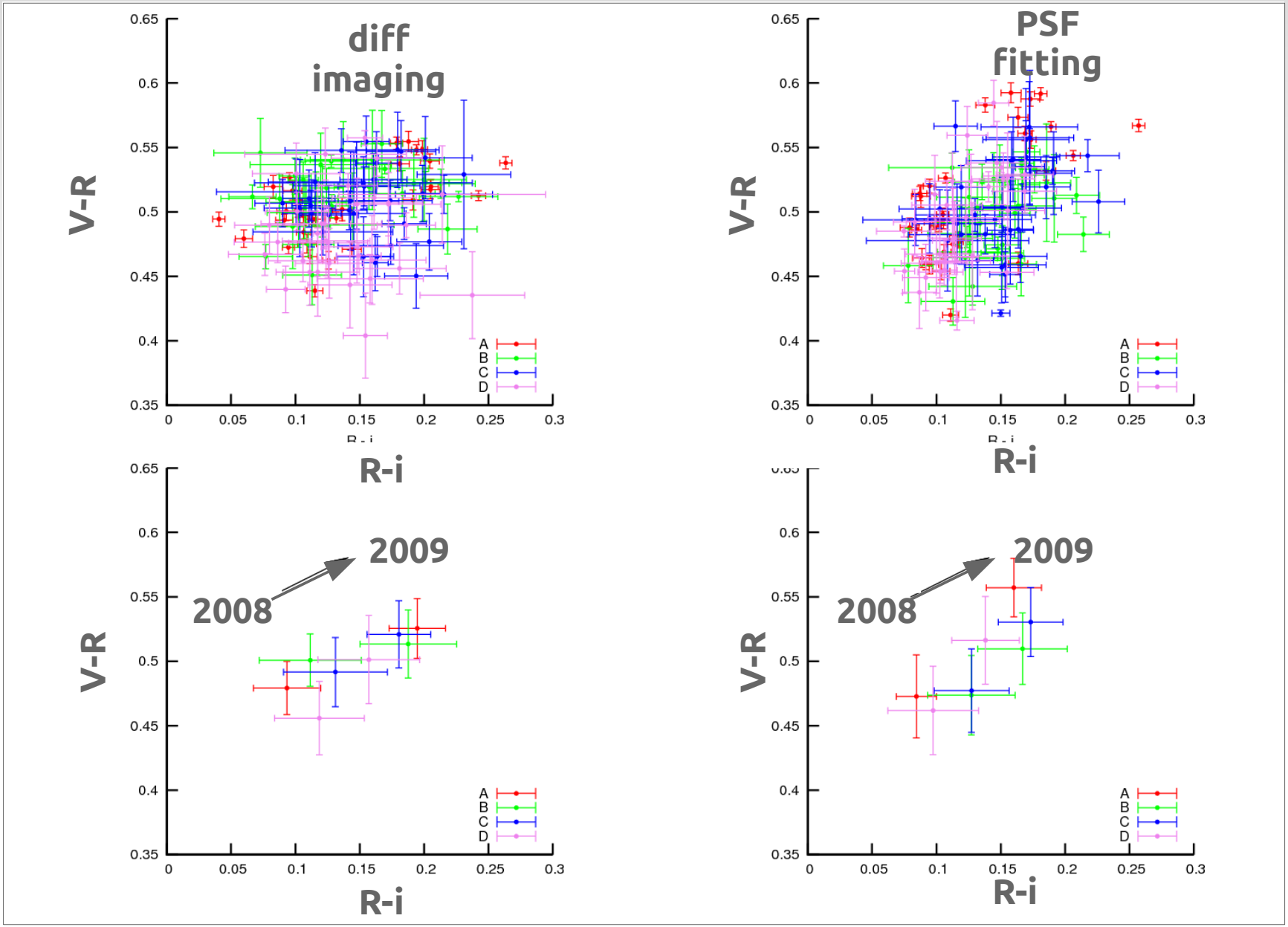




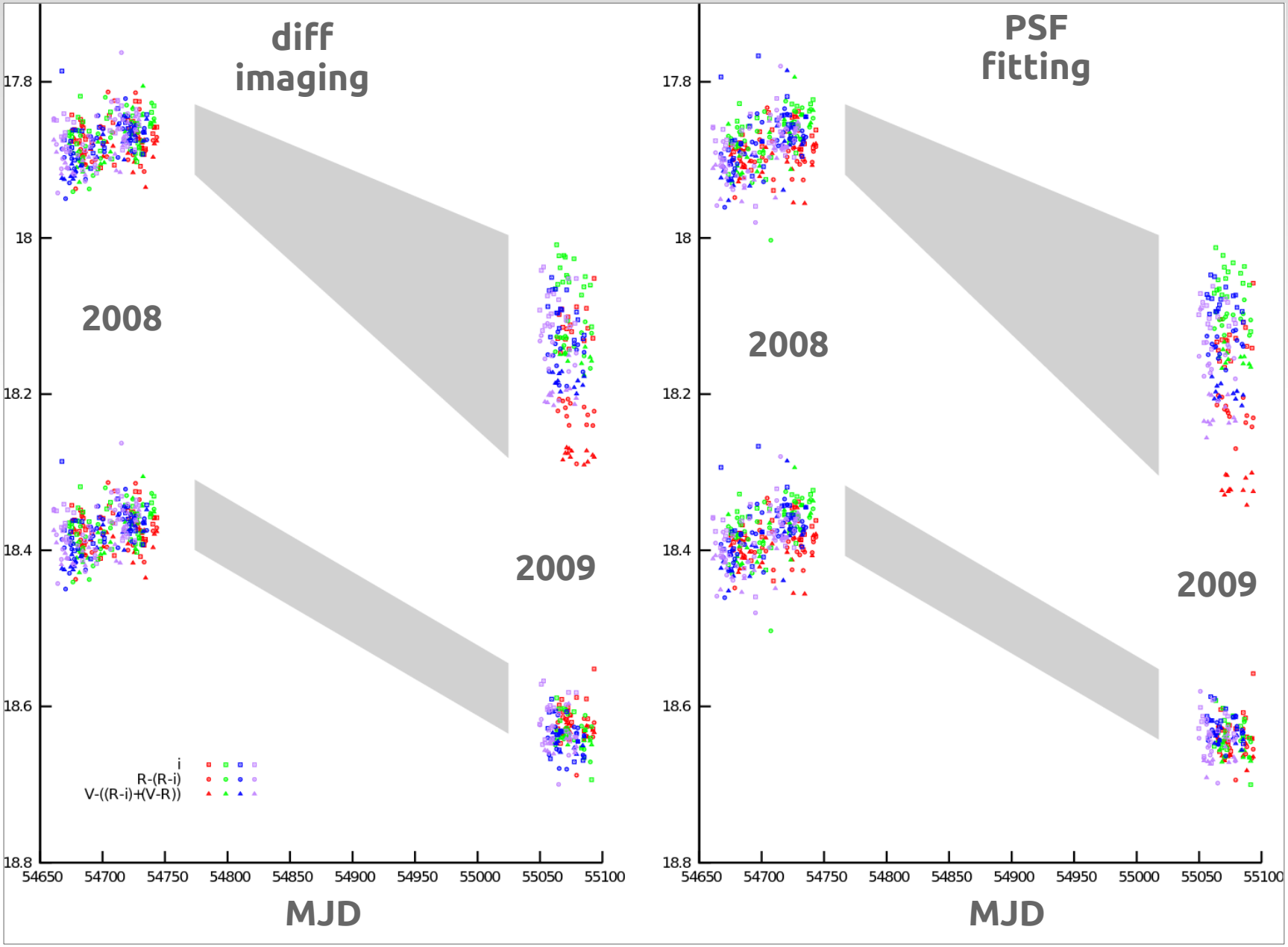
HE0435 light curves

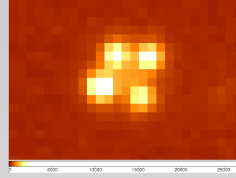


HE0435 color-color diagrams



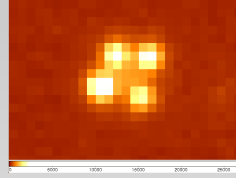
HE0435 “global” curves





HE0435 Results

- Decrease by ≈ 0.2–0.4 magnitudes in all the filters; amplitude slightly larger for component “A” in the V band
- Increase (≈ 0.05–0.015) for V – R and R – i; component “A” shows the largest shift in color
- Variations very likely due to intrinsic variations of the quasar.
- Microlensing effects probably also affect the “A” lensed component.



HE0435 paper

Flux and color variations of the quadruply imaged quasar HE 0435–1223

D. Ricci[1,⋆], J. Poels[1], A. Elyiv[1,2], F. Finet[1], P. G. Sprimont[1], T. Anguita[22,23], V. Bozza[4,5], P. Browne[6], M. Burgdorf[7], S. Calchi Novati[4,19], M. Dominik[6,⋆⋆], S. Dreizler[8], M. Glitrup[9], F. Grundahl[9], K. Harpsøe[10], F. Hessman[8], T. C. Hinse[10,11], A. Hornstrup[17], M. Hundertmark[8], G. Jørgensen[10], C. Liebig[3,6], G. Maier[3], L. Mancini[4,19,21], G. Masi[18], M. Mathiasen[6], S. Rahvar[16], G. Scarpetta[4,5], J. Skottfelt[10], C. Snodgrass[12,20], J. Southworth[13], J. Teuber[10], C. C. Thöne[14,15], J. Wambsganß[3], F. Zimmer[3], M. Zub[3], and J. Surdej[1,⋆⋆⋆]

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[11] Armagh Observatory, College Hill, Armagh, BT61 9DG, UK
[12] European Southern Observatory, Casilla 19001, Santiago 19, Chile
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[14] Dark Cosmology Centre, Niels Bohr Institute, University of Copenhagen, Juliane Maries Vej 30, Copenhagen , 2100 Denmark
[15] INAF, Osservatorio Astronomico di Brera, 23807 Merate, Italy

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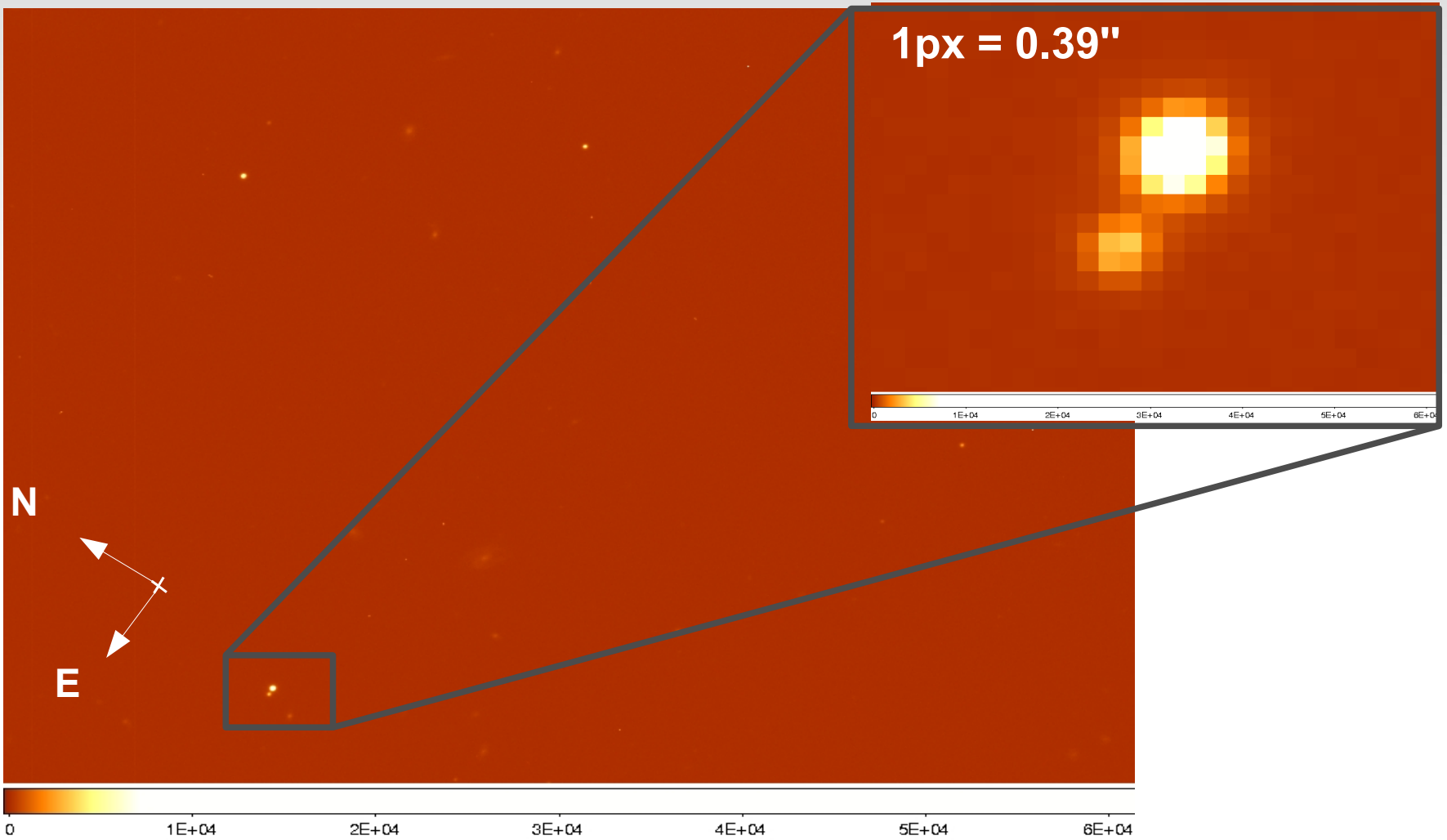
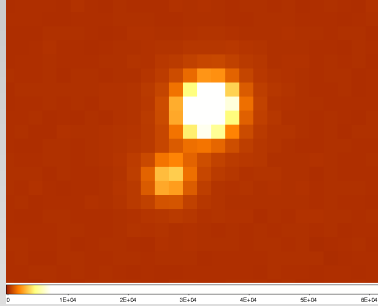
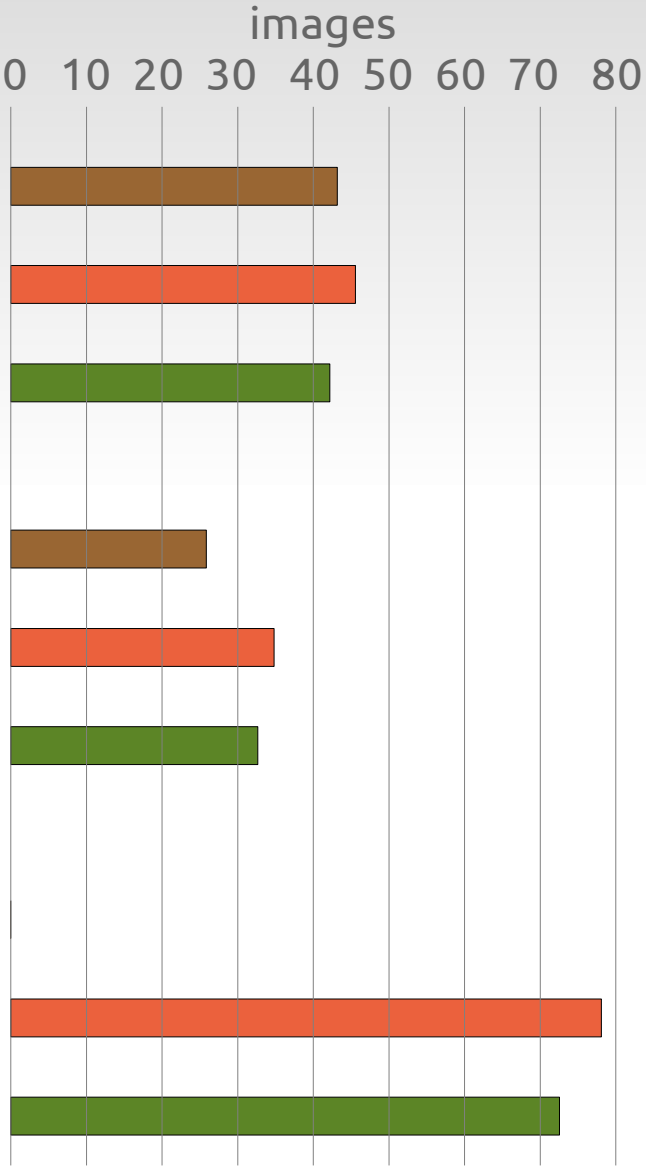
UM673

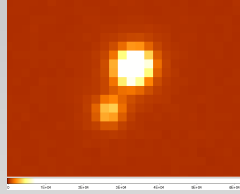


UM673 data



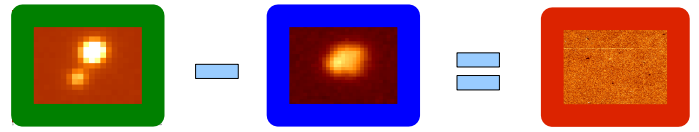
- 130 images in 2008
  - 43 in Gunn i (15 nights)
  - 45 in Bessel R (15 nights)
  - 42 in Bessel V (15 nights)
- 95 images in 2009
  - 26 in Gunn i (9 nights)
  - 35 in Bessel R (12 nights)
  - 34 in Bessel V (13 nights)
- 150 images in 2010
  - 0 in Gunn i (0 nights)
  - 78 in Bessel R (26 nights)
  - 72 in Bessel V (23 nights)

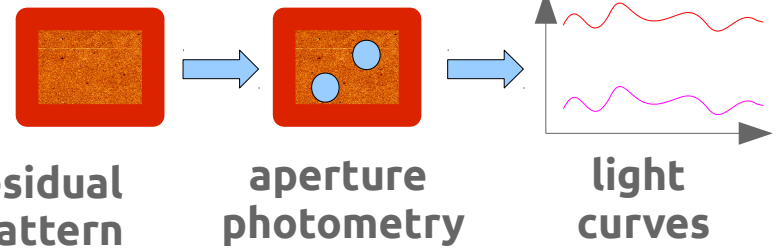




UM673 reduction techniques

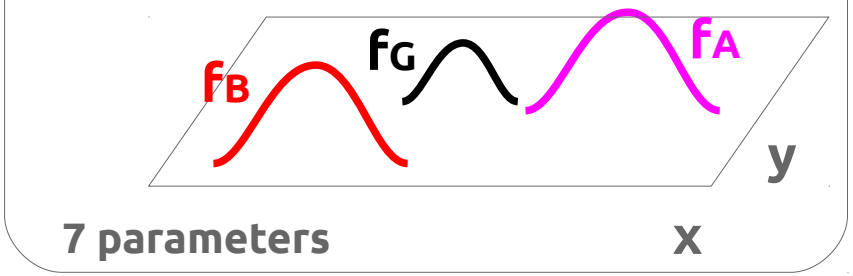
Difference imaging (Joël Poels)

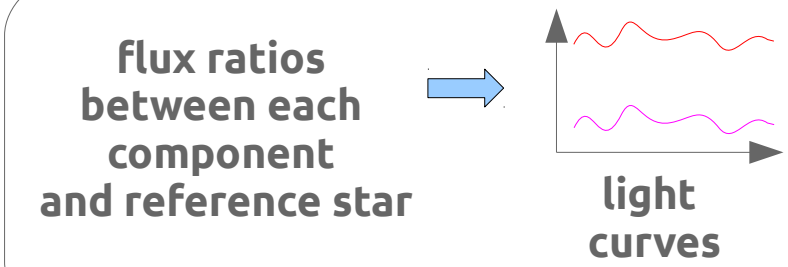


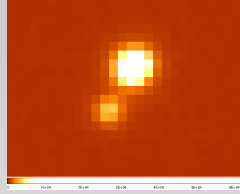


PSF fitting (Andrii Elyiv)

- Choosing a reference star
- Fitting 3 PSF
- coordinates from Kochanek (2006)
- 5 free parameters



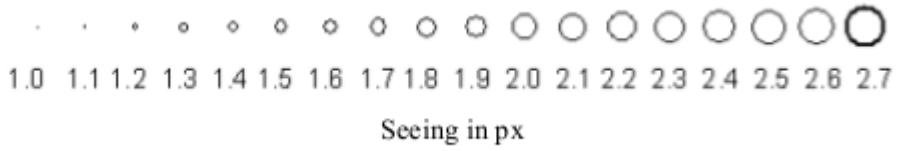


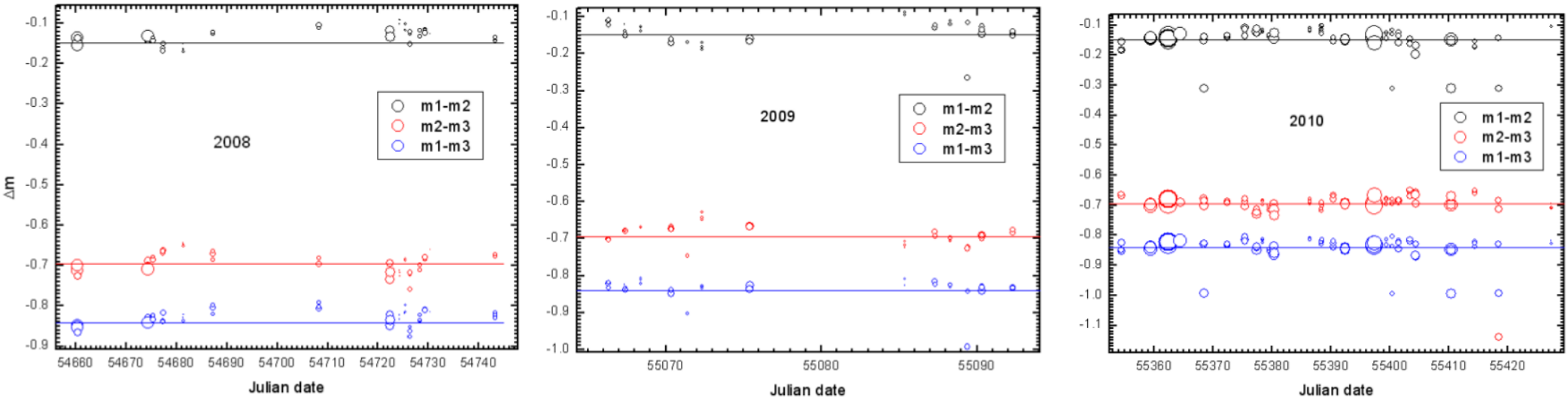


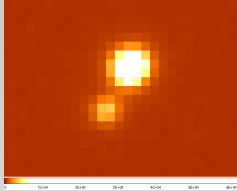
UM673 seeing inspection

- Searching for a suitable reference star
- We want to use only the best seeing nights (one at the beginning and one at the end of the season)
- 3 seasons x 3 images per night x 2 nights = 18 images per filter

Andrii Elyiv report







UM673 paper

- ...in preparation

1. Introduction

Gravitationally lensed quasars are of a great interest in astrophysics due to the possibility, studying the flux and the color variations between the lensed components, to distinguish between the quasars' intrinsic variations, caused by their accretion mechanism, and the microlensing effects, caused by the stars of the lens galaxy.

In paper I (Ricci et al. 2011), we studied such variations on the quadruply imaged quasar HE0435-1223, observed in the framework of a *VRi* multi-epoch monitoring of several lensed quasars[1], a parallel project of the MiNDSTEp (Microlensing Network for the Detection of Small Terrestrial Exoplanets) campaign (Dominik et al. 2010).

In the current paper we focus on UM673/Q0142−100 (See Fig. 1), a doubly imaged quasar discovered by Surdej et al. (1987) during a high resolution imaging survey of HLQs (Highly Luminous Quasars) and deeply studied in our team (Smette et al. 1990, 1992).

Surdej et al. (1988) achieved a separation of 2.22″ between the components "A" (brighter) and "B" (fainter), and found their V magnitudes to be 16.9 and 19.1 respectively, at a redshift $z = 2.719$. The redshift of the sensibly fainter ($R = 19.2$) lensing galaxy, located very close to the "B" component, was calculated at $z = 0.49$, and the time delay between the two lensed components was estimated around 7 weeks.

A photometric coverage of UM673 was effectuated during the years 1987–1993 (Daulie et al. 1993), but the photometry did not show any evidence of relative variations over the considered period.

Sinachopoulos et al. (2001) observed the lensed quasar in the R filter for five years (1995–2000), detecting a significant increase of 0.3 magnitudes of the whole system (lensed components and lens galaxy) with respect of the values achieved at his discovery, with a peak of 0.5 mag in the period 1995–1997. The photometry on HST (Hubbe Space Telescope) R filter images gave values of 16.67, 18.96, and 19.35 for the components "A", "B" and the lens galaxy, respectively.

After the spectrophotometric observations performed on in 2002 by Wisotzki et al. (2004), which did not show any evidence of microlensing, the first multi-filter monitoring of UM673 was carried by Nakos et al. (2005) between 1998 and 1999, in the Gunn i and Cousins V filters. The analysis of the light curves was effectuated using three different photometric methods: image deconvolution, PSF (Point Spread Function) fitting, and differential imaging. Nakos et al. (2005) found that component "A" displayed possible evidence for microlensing.

Between 2003 and 2005, Koptelova et al. (2008, 2010) observed

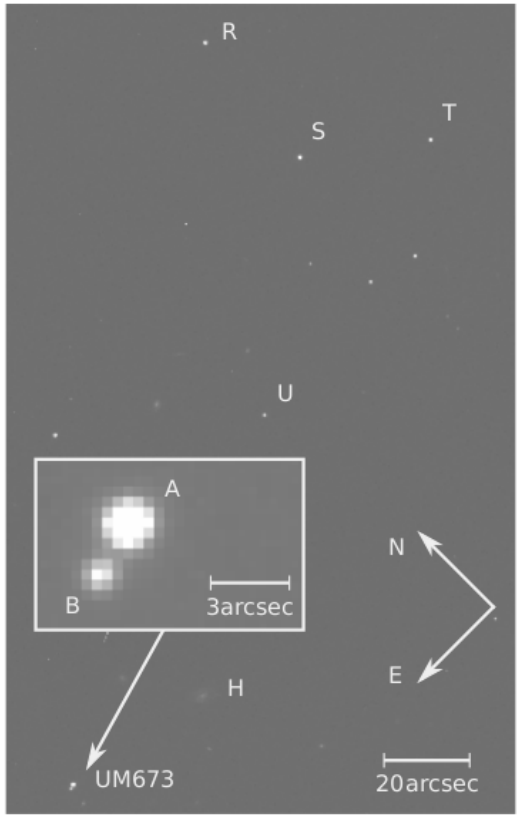


Fig. 1. DFOSC V filter image, taken on 2008-08-03, showing the position of UM673 and the stars "R", "S", "T", and "U" used to search for a suitable reference star. The "R" star was finally chosen. The label "H" indicates a field galaxy. The inset zoom shows the two components "A" and "B" of the lensed quasar.

2. Observations and pre-processing

We monitored UM673 during three seasons (2008–2010) using the Danish 1.54m telescope at the La Silla Observatory equipped with the DFOSC instrument, able to provide 2147 × 2101pixel CCD frames covering a field of view of 13.7′ × 13.7′ with a res-

HE0435 color indices using only good seeing images