

Limb-Darkening Measurement for a Cool Red Giant in Microlensing Event: OGLE 2004-BLG-482

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PLANET Collaboration

OGLE Collaboration

MicroFUN Collaboration

13th Microlensing Workshop, Paris, 19-21st Jan 2009



International Max Planck Research School
for Astronomy and Cosmic Physics at the University of Heidelberg





OGLE 2004-BLG-482: Measuring the Limb Darkening of a Source Star by Microlensing

Outline:

- **Limb-darkening effect with microlensing**
- **Light-curve modelling**
- **Source star of OGLE 2004-BLG-482 - cmd**
- **Stellar parameters from spectroscopy**
- **Analysis of the results**
- **Summary**



Limb-darkening measurement by microlensing so far

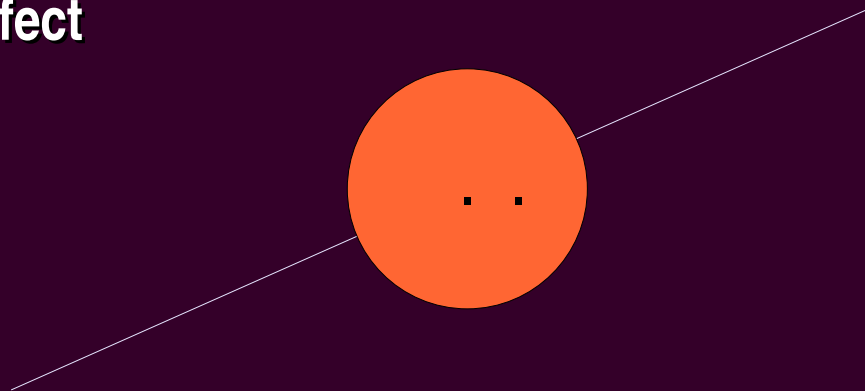
Up to now the limb-darkening measurements of a source star by microlensing was done:

- in Galactic bulge for:
 - a F–G main sequence star,
 - a G/K subgiant,
 - a few of G and K giants,
 - two M giants,
- in Small Magellanic Cloud for: an A dwarf.



How does the microlensing method work?

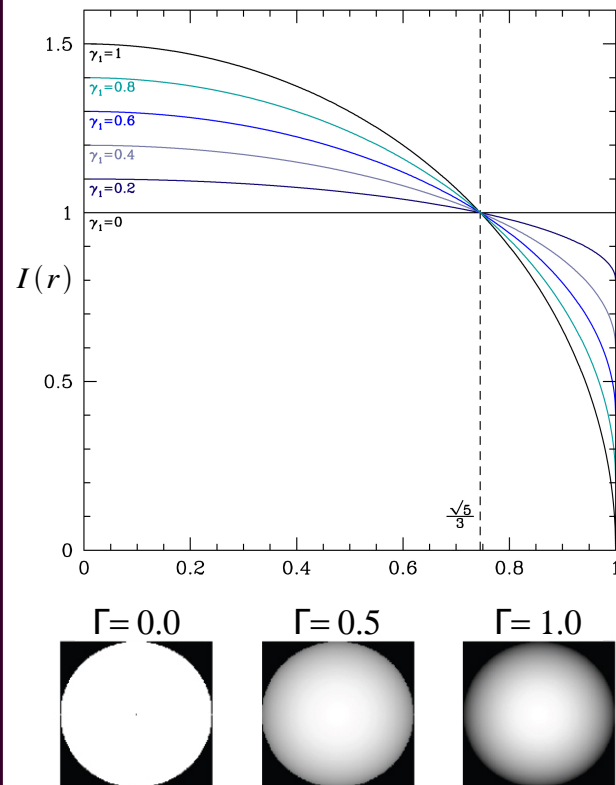
- Passage near a caustic $\Rightarrow$ large magnification gradient:
 - ➔ high magnification of the source star,
 - ➔ differential magnification of its surface
- Spatial resolution of the source star's surface $\longrightarrow$ extended source effect



Limb-Darkening Effect

- The magnification gradient provides measurements of the stellar limb-darkening (LD)

Stellar limb-darkening



Linear LD law

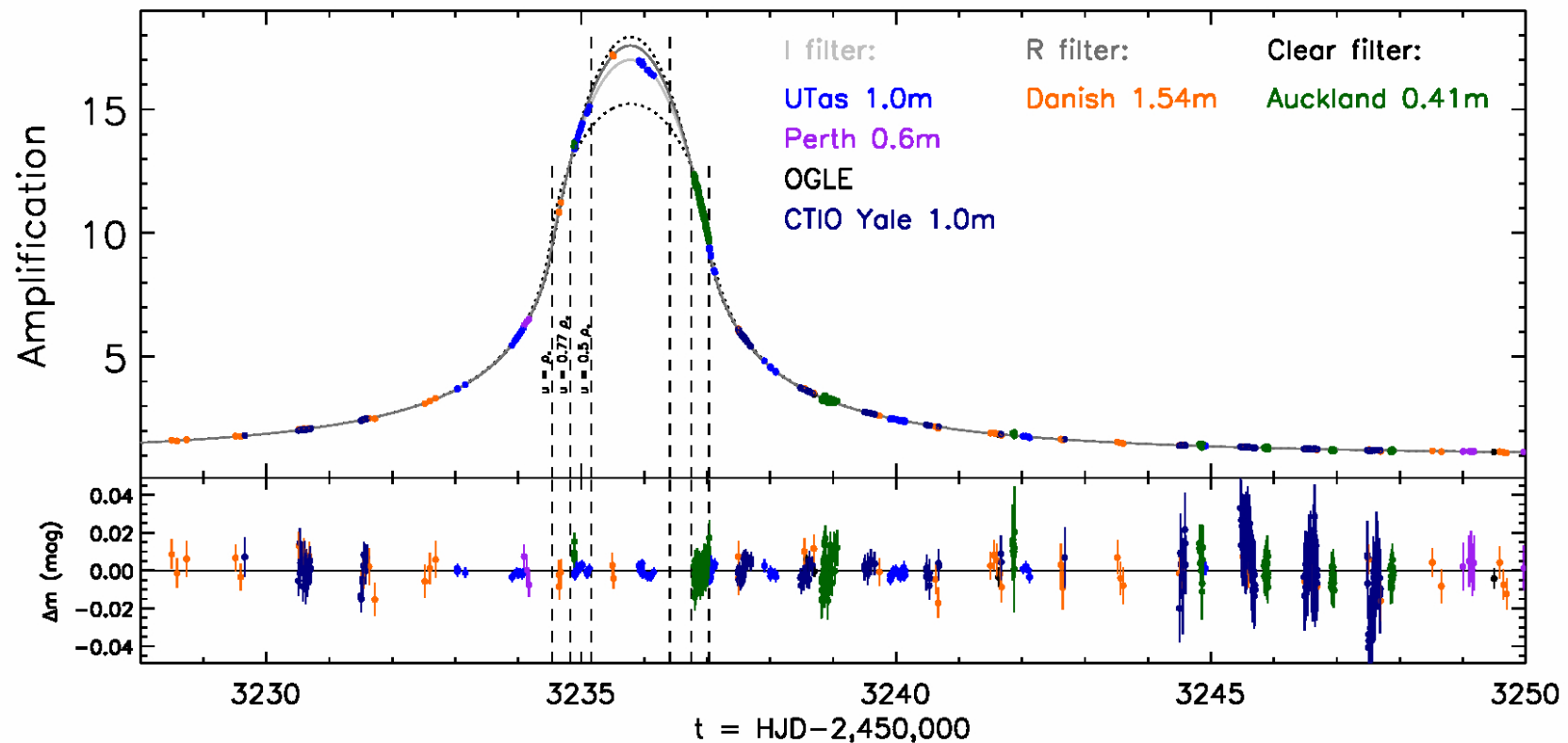
$$I(r) = \frac{1}{\pi} \left[1 - \Gamma \left(1 - \frac{3}{2} \sqrt{1-r^2} \right) \right]$$

$$a = \frac{3\Gamma}{2 + \Gamma}$$



OGLE 2004-BLG-482 modelling

Measurement of the source star's limb-darkening



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- Modelling the point lens limb-darkened extended source model with a linear limb-darkening law
- Photometric data from: OGLE, PLANET and MicroFUN

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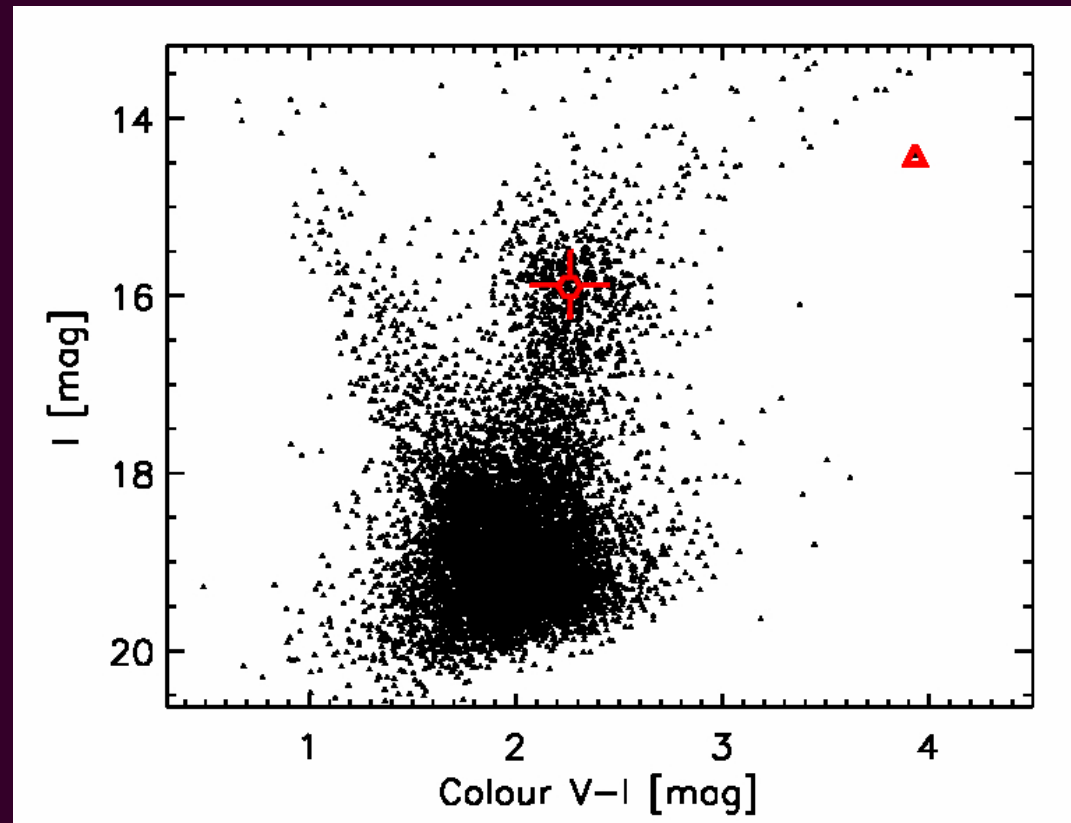
Calibrated OGLE colour-magnitude diagram

Data from BUL_SC23 OGLE II field

Estimated corrected from
absorption magnitude and
colour of the target
(using Sumi 2004):

$$I_0 = 12.99 \pm 0.05$$

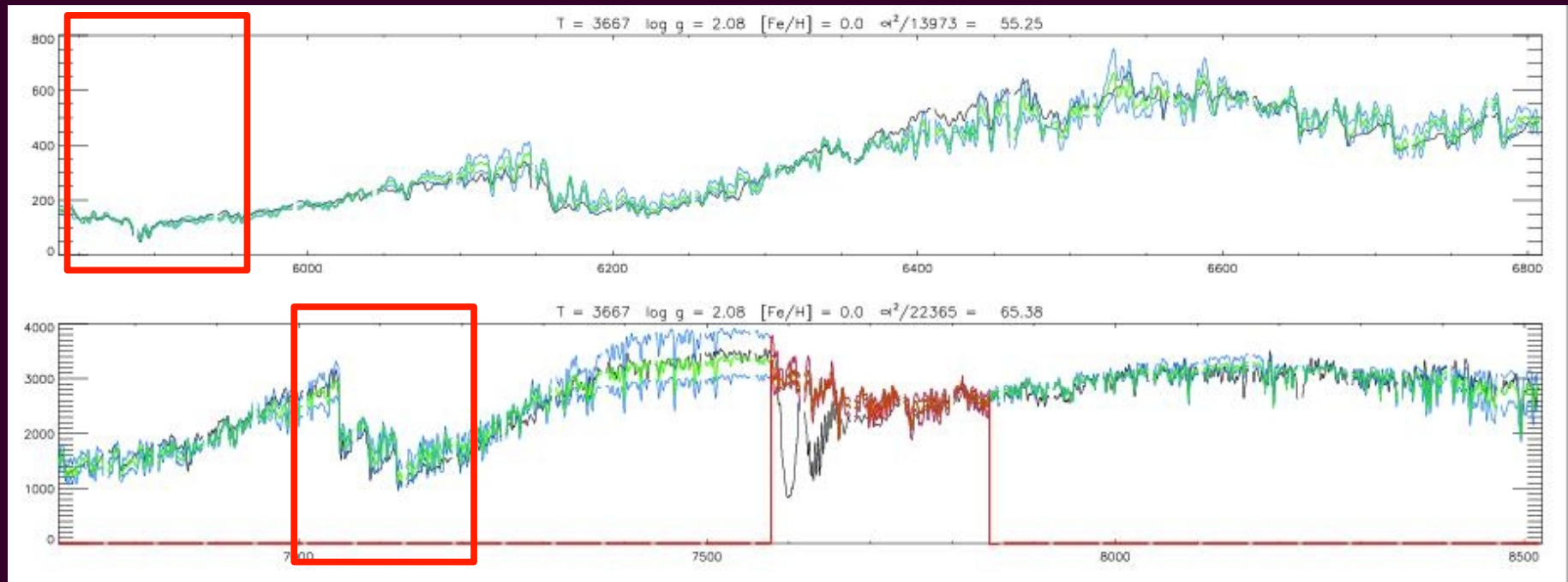
$$(V-I)_0 = 2.53 \pm 0.04$$



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Source star characteristics from spectroscopy

Na I D 5890 Å



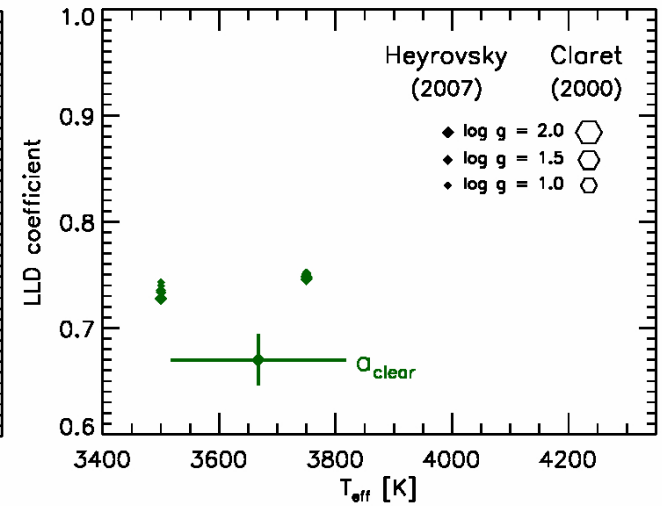
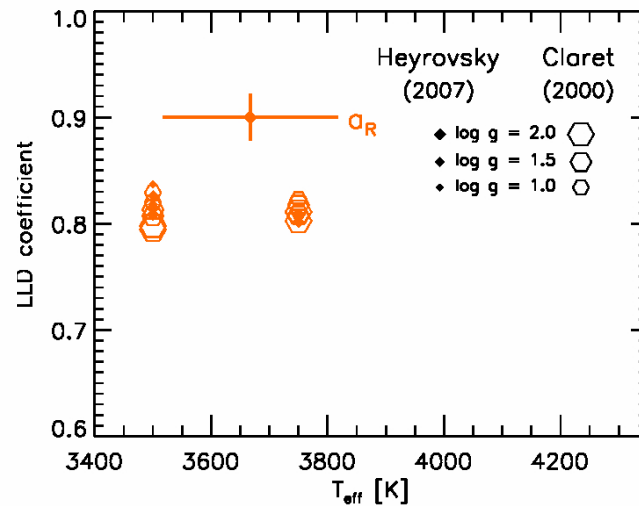
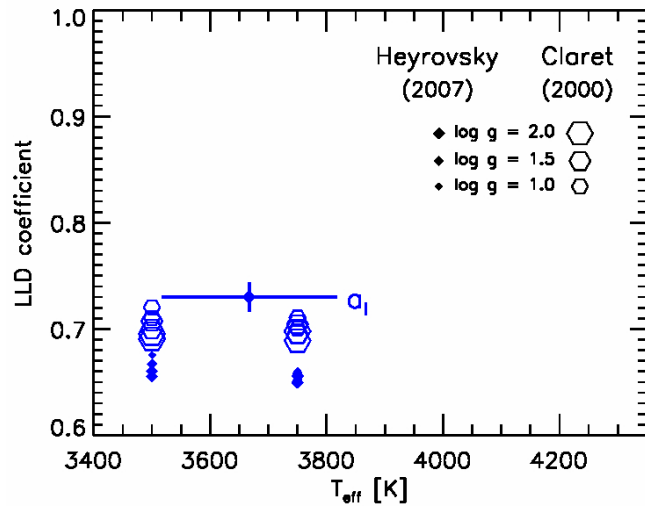
TiO 7100 Å

VLT/UVES high resolution spectrum

- **Stellar parameters which best fit the observed spectrum:**
 $T_{\text{eff}} = 3667 \pm 150$ K, the surface gravity $\log g = 2.1 \pm 1.0$ for solar metallicity
- **Estimated spectral type of source star:** an M1 giant



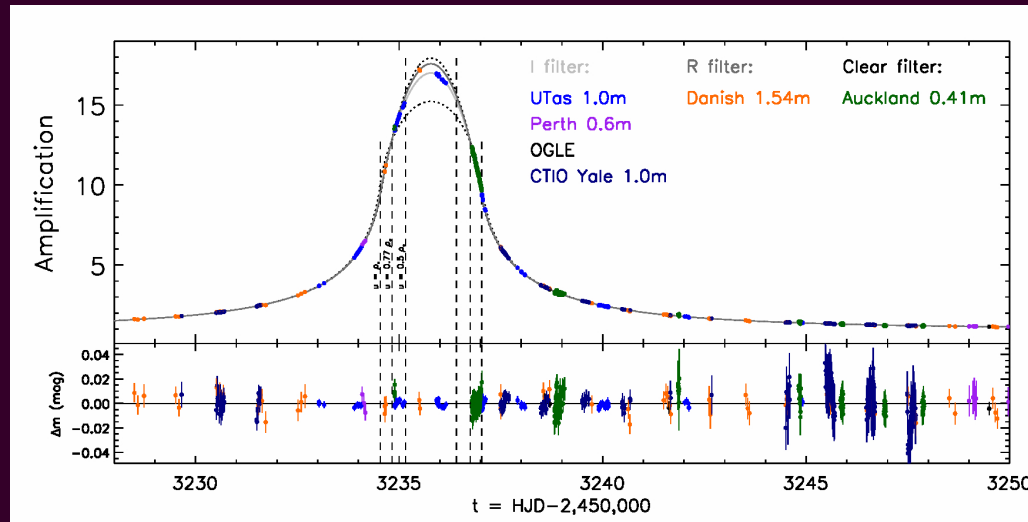
Analysis of the measured linear limb-darkening coefficients (LLDC)



Comparison of our results with theoretical LLD coefficients from Kurucz's ATLAS stellar atmosphere models for:

$T_{\text{eff}} = 3500 \text{ K}, T_{\text{eff}} = 3750 \text{ K}, \log g = 1.0 \text{ cm/s}^2, \log g = 1.5 \text{ cm/s}^2, \log g = 2.0 \text{ cm/s}^2, [M/H] = 0.0$

(VizieR database)



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Summary

- **OGLE 2004-BLG-482 source star – an M giant star with a good agreement from spectroscopic and photometric analysis**
- **Linear limb-darkening coefficients measurements in *I* and *R*-band**
- **Comparison of the theoretical models with the observational results**