Università del Salento and INFN Lecce

Dipartimento di Matematica e Fisica
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Stellar Spot Features in Microlensing Events

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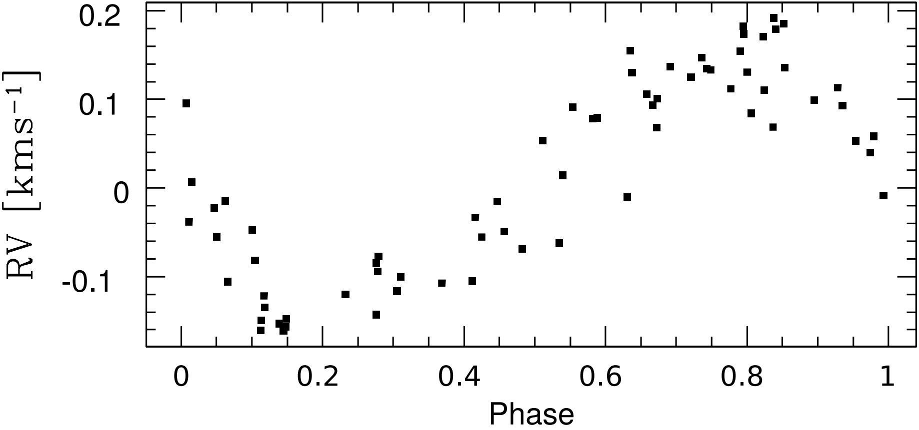
No planet for HD 166435 (D. Queloz et al. *A&A* **379**, 279-287 (2001). DOI: 10.1051/0004-6361:20011308. arXiv: astro-ph/0109491v1.)



Credits: I. Boisse, X. Bonfils, and N. C. Santos. *A&A* **545**, A109, (2012). DOI: 10.1051/0004-6361/201219115. arXiv: 1206.5493.

Stellar Spots and Radial Velocity

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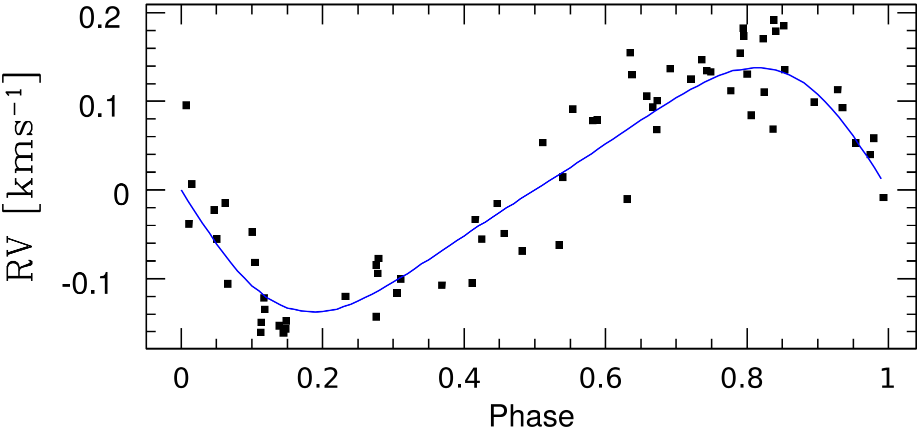

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Amplification with Stellar Spots on the Source

We consider the amplification of a source star, with spots on its surface, by a point-like single lens.
We calculate the finite source amplification A_{finite} numerically on the source disk $\mathcal{S}$ using

$$A_{\text{finite}} = \frac{\int_{\mathcal{S}} A(\boldsymbol{r}) f(\boldsymbol{r})\, \mathrm{d}\boldsymbol{r}}{\int_{\mathcal{S}} f(\boldsymbol{r})\, \mathrm{d}\boldsymbol{r}} = \frac{\int_{\mathcal{S}} A(\boldsymbol{r}) f(\boldsymbol{r})\, \mathrm{d}\boldsymbol{r}}{F}$$

with $A(\boldsymbol{r})$ the Paczyński amplification, $f(\boldsymbol{r})$ the surface brightness, and $F = \int_{\mathcal{S}} f(\boldsymbol{r})\, \mathrm{d}\boldsymbol{r}$ the total flux of the source.
For simplicity we assume $f(\boldsymbol{r})$ to be given only by the Stefan–Boltzmann law:

$$f(\boldsymbol{r}) = \begin{cases} \text{const} & \text{if } \boldsymbol{r} \text{ is outside the spot,} \\ \text{const}(T_{\text{spot}}/T_{\text{star}})^4 & \text{if } \boldsymbol{r} \text{ is inside the spot.} \end{cases}$$

We set $(T_{\text{spot}}/T_{\text{star}})^4 = \tau$.

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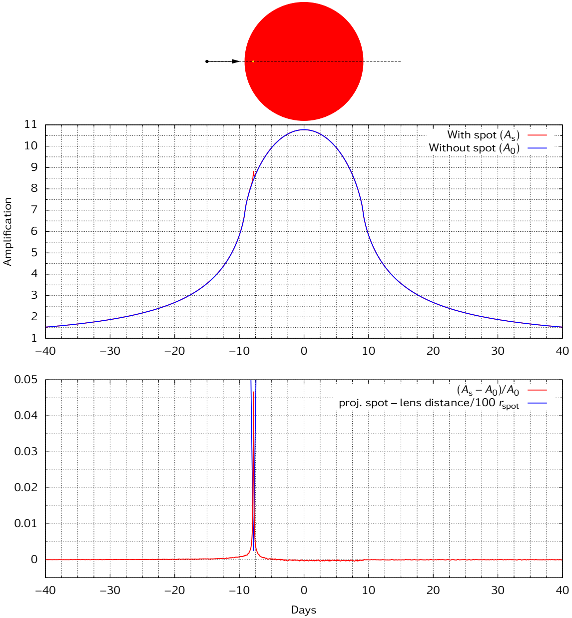
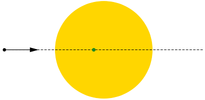
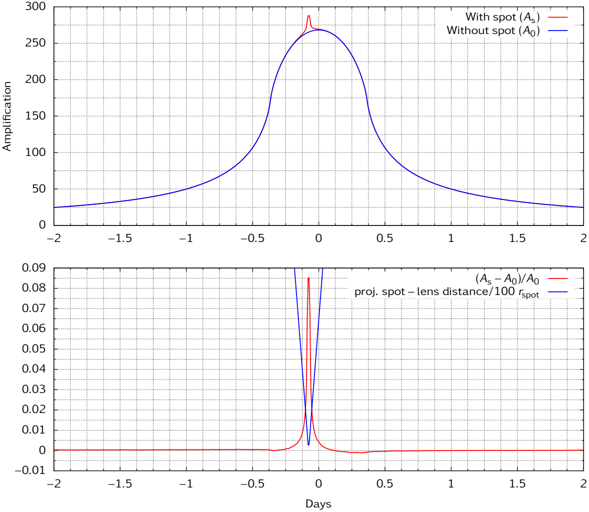
Simulation 1: red supergiant with one hot spot



- $D_l/D_s = 0.5$
- $R_{source} = 50 R_\odot$
- $P_{source} = 500$ days
- $t_E = 49.1$ days
- $\theta_{spot} = 0$
- $\tau = 8$
- $R_{spot}/R_{source} = 0.008$

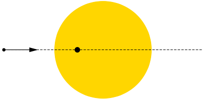
Simulation 2: main sequence star with one hot spot

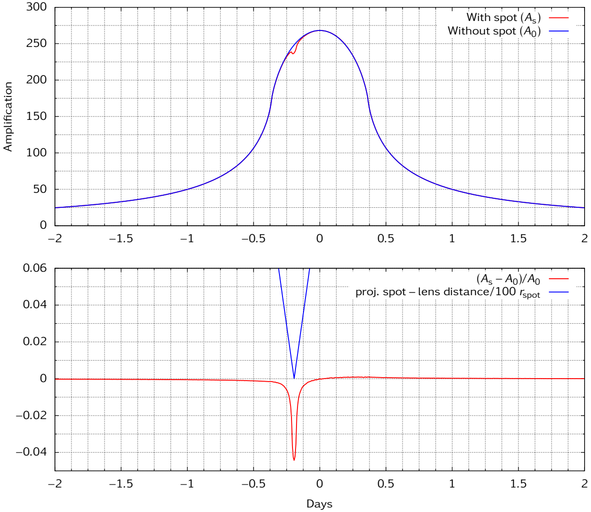




- $D_l/D_s = 0.5$
- $R_{source} = 2R_\odot$
- P_{source} = 30 days
- t_E = 49.1 days
- $\theta_{spot} = 0$
- $\tau = 4$
- $R_{spot}/R_{source} = 0.03$

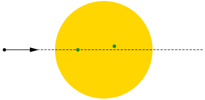
Simulation 3: main sequence star with one cold spot

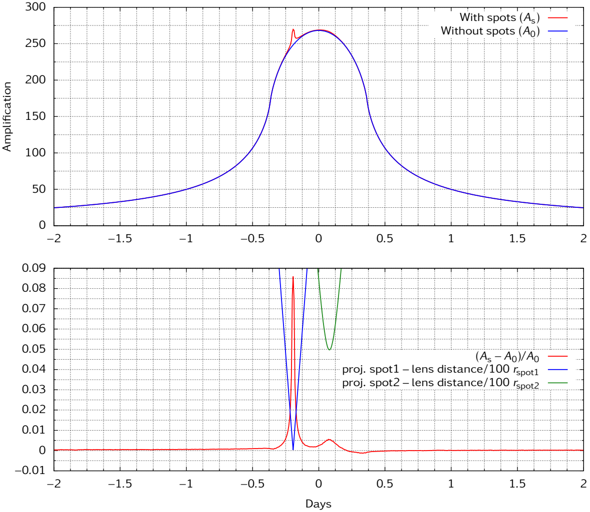




- $D_l/D_s = 0.5$
- $R_{source} = 2R_\odot$
- $P_{source} = 30$ days
- $t_E = 49.1$ days
- $\theta_{spot} = 0$
- $\tau = 0.07$
- $R_{spot}/R_{source} = 0.05$

Simulation 4: main sequence star with two hot spots





- $D_l/D_s = 0.5$
- $R_{source} = 2R_\odot$
- $P_{source} = 30$ days
- $t_E = 49.1$ days
- $\theta_{spot\ 1} = 0$
- $\theta_{spot\ 2} = \pi/21$
- $\tau_1 = \tau_2 = 4$
- $R_{spots}/R_{source} = 0.03$

Conclusions

These features are peculiar to microlensing events by a single lens and with a spot on the source surface:

- important finite source effects (giant source or lens close to the source)
- secondary (spot-induced) peak pretty close (or at least within the angular size of the source) to peak of closest approach between lens and source

The following features are peculiar to microlensing events by binary lenses:

- very high amplification event
- secondary peak far from the main one
- an asymmetric amplification curve cannot be due to a single lens (it would be Paczyński-like in that case), if parallax is not important
- very large enhancement factor compared to the amplification curve with unspotted source
- double caustic crossing

Conclusions (cont.)

In addition we note that

- cold spots are easier to distinguish from a real binary lens than hot ones
- only spots along the lens trajectory (or very close to it) sensibly affect amplification curve profile

Reference

M. Giordano, et al. *In Preparation*.

Contact Us

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