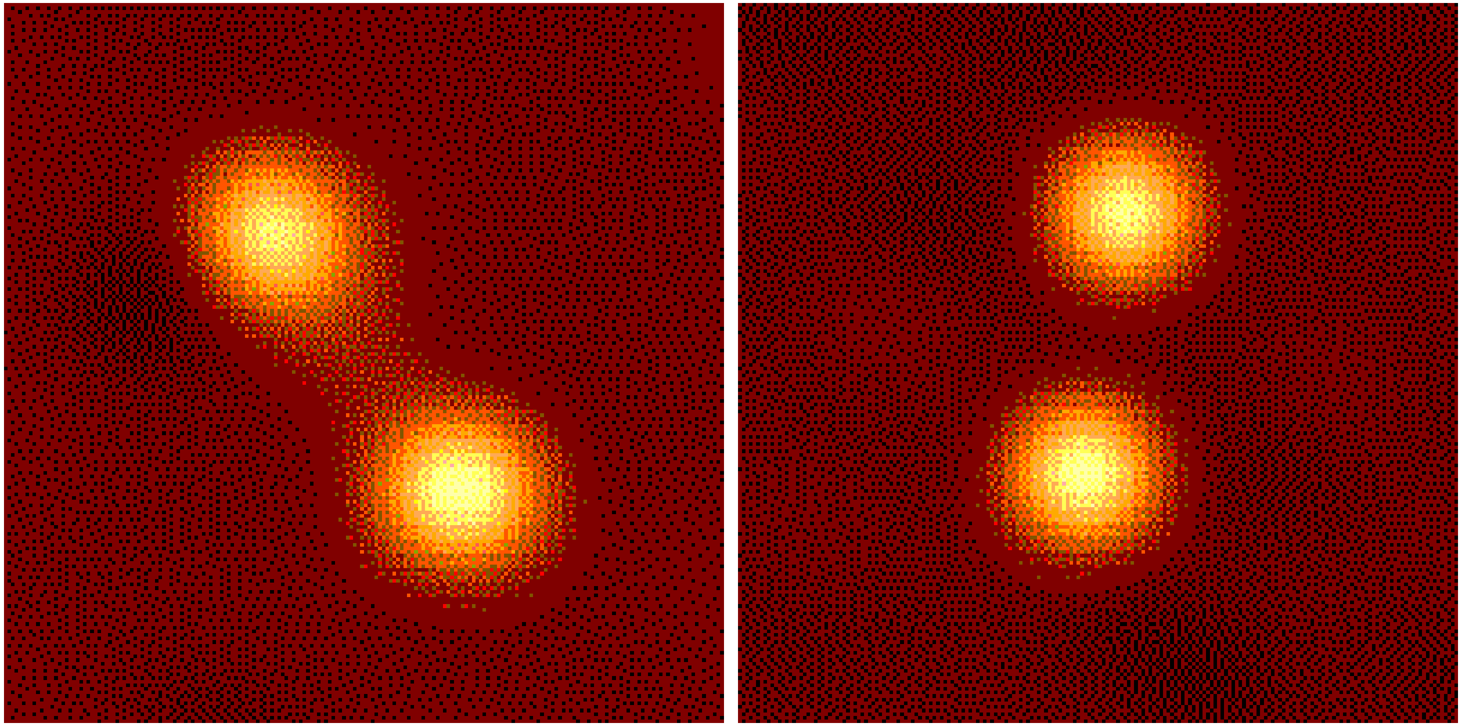
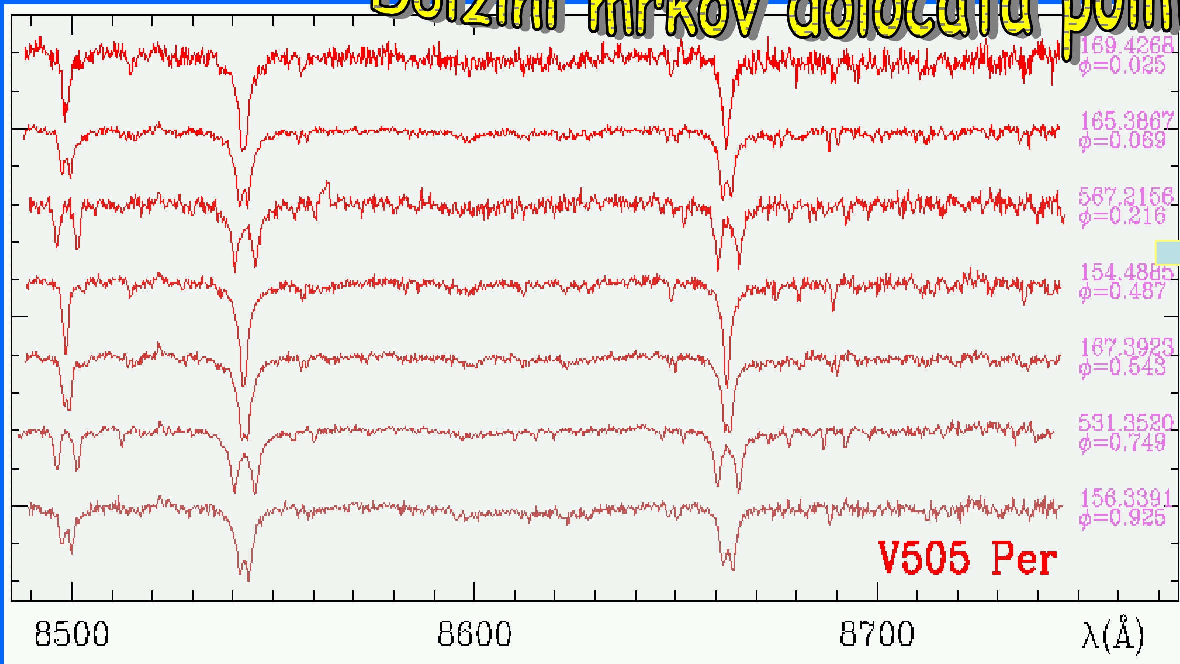
Vizualne dvojnice

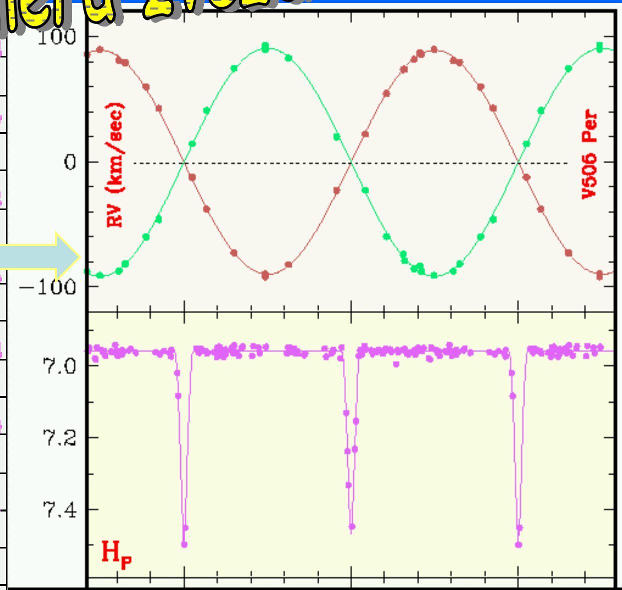


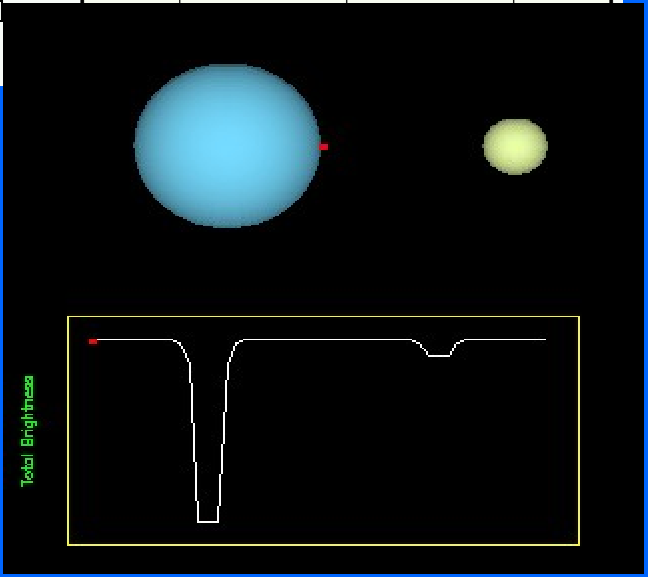
Images of Capella taken on the 13th (left) and 28th (right) September 1995. The separation between the stars is 55 milli-arcsec.

Prekrivalne dvojne zvezde

Dolžini mrkov določata polmera zvezd







a = 15.06 +/- 0.08 R_o

M_1 = 1.30 +/- 0.02 M_o
M_2 = 1.28 +/- 0.02 M_o

R_1 = 1.40 +/- 0.02 Ro
R_2 = 1.14 +/- 0.03 Ro

T_1 = 6460 +/- 50 K

T_2 = 6415 +/- 50 K

razdalja: 60 +/- 3 pc Asiago/GAIA
66 +/- 4 pc Hipparcos

Spectroscopy of A0620 − 00: the mass of the black hole and an image of its accretion disc

T. R. Marsh,[1] E. L. Robinson[2] and J. H. Wood[3]

[1] University of Oxford, Department of Physics, Nuclear Physics Laboratory, Keble Road, Oxford OX1 3RH
[2] University of Texas, Department of Astronomy, Austin, TX 78712, USA
[3] Keele University, Department of Physics, Keele ST5 5BG

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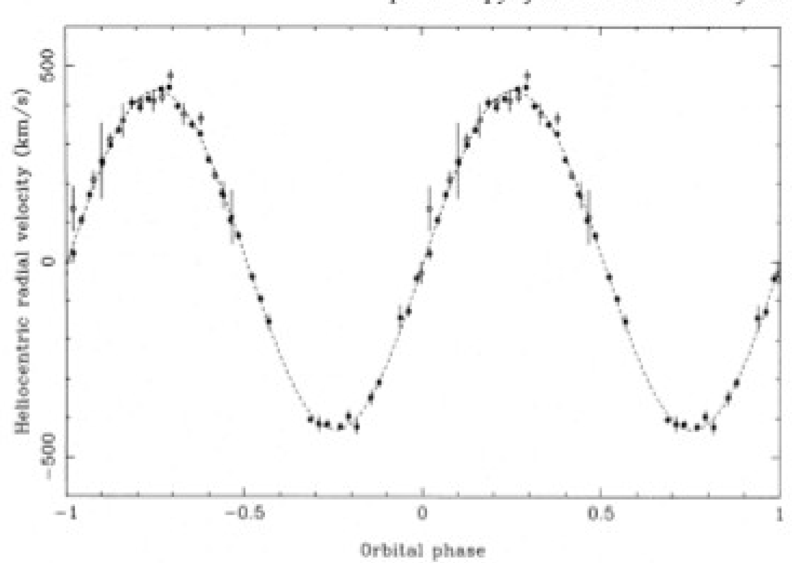


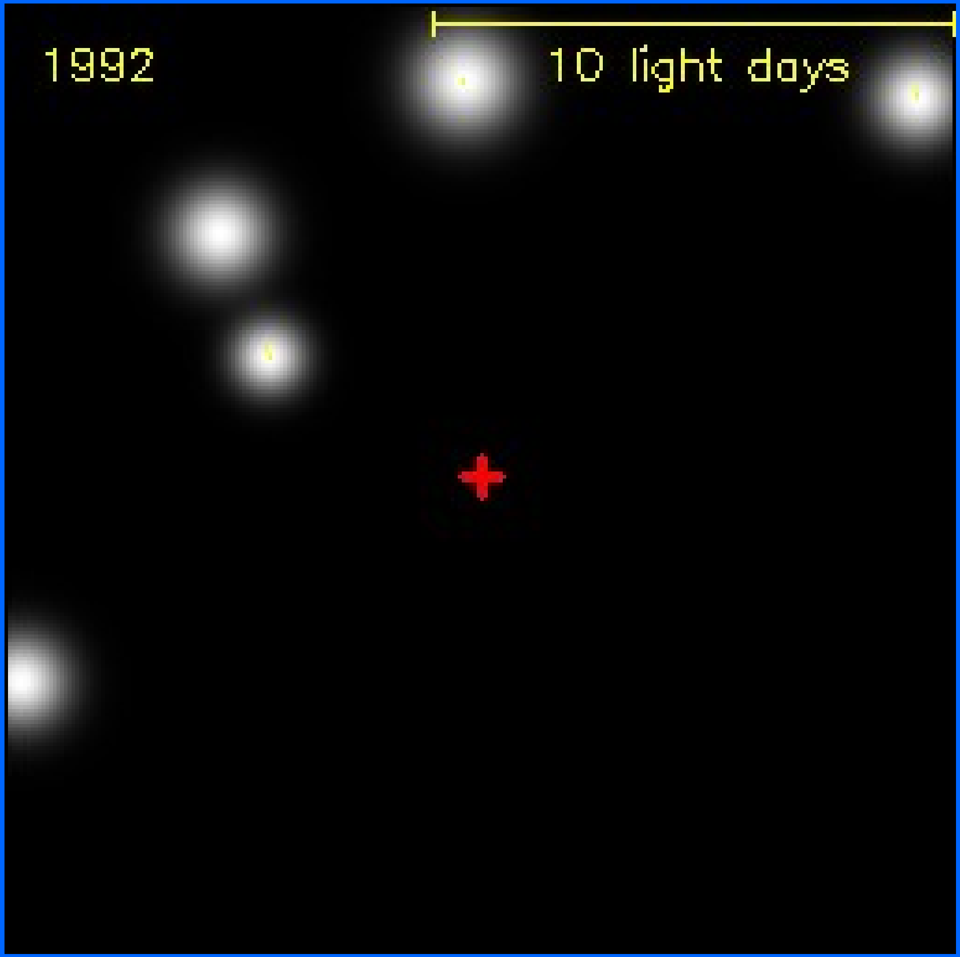
ABSTRACT

We present spectra of the black hole binary A0620 − 00 taken at Hα and Hβ to study the distribution of emission-line flux from its accretion disc. Using the spectra of Hα, we have measured the K-type companion star's radial velocity semi-amplitude and rotational broadening to be $K_2 = 433 \pm 3$ km s^{-1} and $v \sin i = 83 \pm 5$ km s^{-1}. Accounting for the Roche-lobe geometry of the companion, the rotational broadening gives the mass ratio $q = M_2/M_1 = 0.067 \pm 0.01$. The disc contributes 6 ± 3 per cent of the light at Hα and 17 ± 3 per cent at Hβ, with the K star providing the rest. The masses of the compact object and K star derived from our values of K_2 and q are $M_1 = (3.09 \pm 0.09) \sin^{-3} i$ M$_\odot$ and $M_2 = (0.21 \pm 0.04) \sin^{-3} i$ M$_\odot$. Applying a constraint upon the orbital inclination, i, from an eclipse found in an earlier study, we obtain 2σ ranges on the masses of $3.30 < M_1 < 4.24$ M$_\odot$ and $0.15 < M_2 < 0.38$ M$_\odot$. The lower limit on the mass of the compact object is higher than the maximum mass of a rotating neutron star based upon equations of state for nuclear material.

Subtraction of the correctly broadened template star removes all lines other than a line at 6708 Å which we identify as Li I 6707.8 Å, which has recently been found in another black hole binary, V404 Cyg. The equivalent width of this line in A0620 − 00 is 160 ± 30 mÅ compared to 290 ± 50 mÅ in V404 Cyg.

Doppler images of the Balmer lines are very similar to those of quiescent dwarf novae, with emission from the region where the gas stream hits the disc and emission from the stream itself prior to this point. The Balmer decrement steepens towards the outer edge of the disc. The impact point gives a disc radius of $\approx 0.5 R_{L1}$, where R_{L1} is the inner Lagrangian point distance, consistent with the separation of the emission-line peaks. In general, the spectra appear to be of lower excitation than those of dwarf novae, with no He II 4686 emission, weak He I emission and Balmer emission of large equivalent width. There is thus very little ionizing radiation in the system, and a rough analysis suggests that the accretion rate on to the compact object must be less than about 4×10^{12} g s^{-1}.

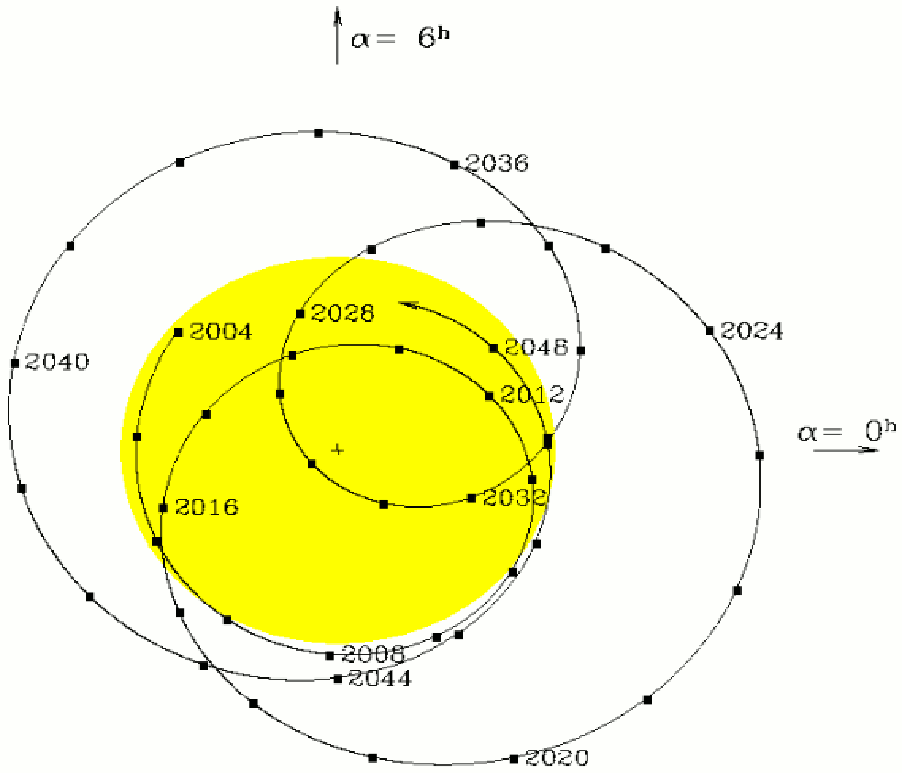
Key words: accretion, accretion discs – black hole physics – binaries: close – stars: individual: A0620 − 00 – stars: rotation –X-rays: stars.


1992
10 light days

Planeti okoli drugih zvezd: načini odkrivanja: astrometrija

$$r_{☼} = r_{\text{planet}}\,(m_{\text{planet}}/M_{☼})$$

Pentljasta krivulja označuje položaj težišča Osončja glede na položaj središča Sonca (znak +). Rumeni krog je velikost Sonca. Pike na krivulji označujejo položaj težišča ob začetku vsakega koledarskega leta.



Načini odkrivanja: astrometrija

$$r_{\odot} = r_{planet} \left(m_{planet} / M_{\odot} \right)$$

$$v_{planet} = 2 \pi r_{planet} / P$$

$$v_{planet}^2 / r_{planet} = G M_{\odot} / r_{planet}^2$$

$$r_{\odot} = (2\pi)^{-2/3} G^{1/3} m_{planet} (M_{\odot})^{-2/3} P^{2/3}$$

Če je za planet z maso Jupitra, ki kroži okoli zvezde z maso Sonca, perioda 2 leti, je $r_{\odot}$ enak 0,32 polmera Sonca.

Načini odkrivanja: astrometrija

$$r_{☼} = (2\pi)^{-2/3} G^{1/3} m_{planet} (M_{☼})^{-2/3} P^{2/3}$$

0,32 polmera Sonca vidimo na razdalji
1,3 pc pod kotom 1,2 mas = 5,7 mm na razdalji 1000 km;
100 pc pod kotom 15 μas = 0,07 mm na razdalji 1000 km.

Načini odkrivanja: spektroskopija

$$r_{☼} = r_{planet}(m_{planet}/M_{☼})$$

$$v_{☼} = 2\pi r_{☼}/P \qquad v_{planet} = 2\pi r_{planet}/P$$

$v_{planet} = (GM_{☼}/r_{planet})^{1/2}$, kjer je $M_{☼}$ masa zvezde.

$$v_{☼} = (GM_{☼}/r_{planet})^{1/2}(m_{planet}/M_{☼})$$

3. Keplerjev zakon mi da r_{planet}, iz zadnje enačbe tako dobim m_{planet}.

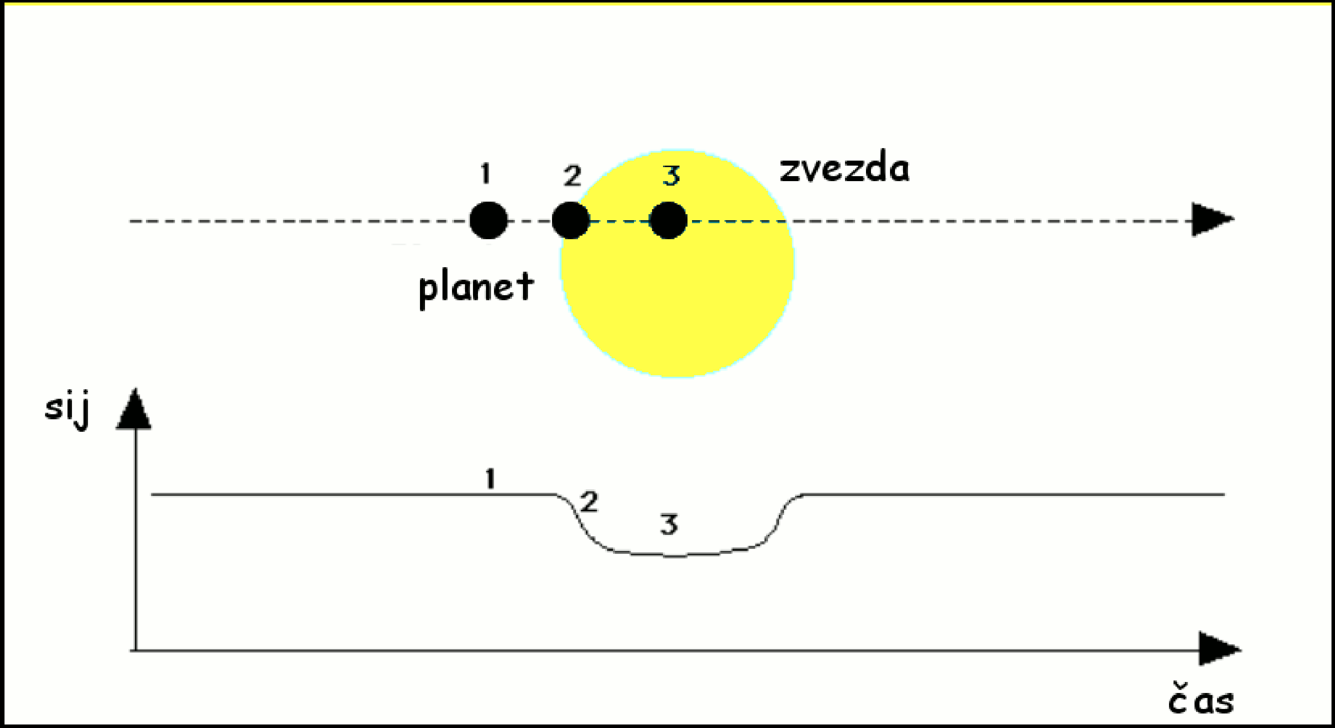
Spektroskopija: ocena temperature na planetu

$$(1-a_P)\,[L_{\odot} / (4\pi\, r_P^2)]\,(\pi R_p^2) = (4\pi\, R_P^2)\,\sigma\, T_P^4$$

$$T_P = [(1-a_P)\, L_{\odot} / (16\pi\, \sigma\, r_P^2)]^{1/4}$$

Opazovanje potemnitve zvezde

Planet prekrije del ploskve zvezde.

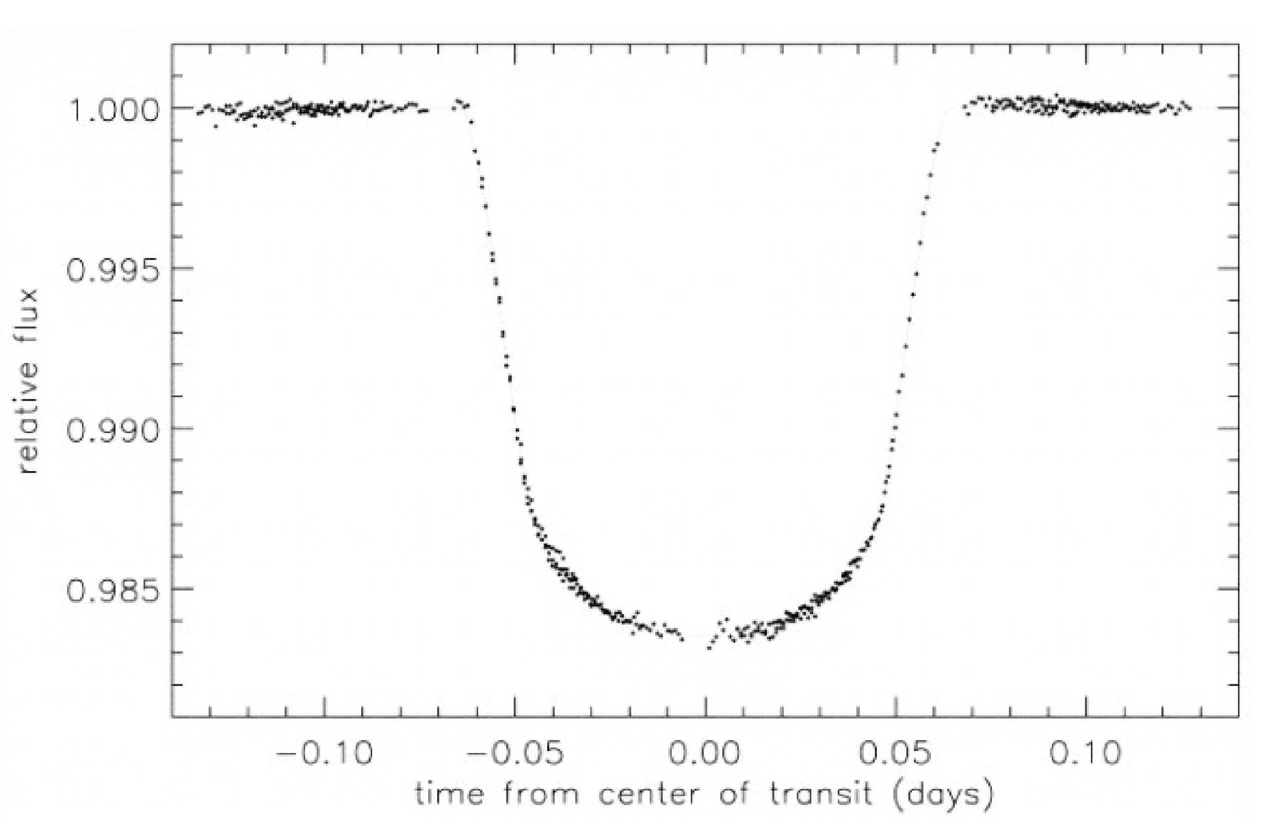


$$(j_{\text{zunaj prehoda}} - j_{\text{med prehodom}})/j_{\text{zunaj prehoda}} = (\pi\, R_{\text{planet}}^{2}) \,/\, (\pi\, R_{\text{☼}}^{2}) = (R_{\text{planet}} \,/\, R_{\text{☼}})^{2}$$

Delež potemnitve zvezde ob prehodu planeta.

Opazovanje potemnitve zvezde

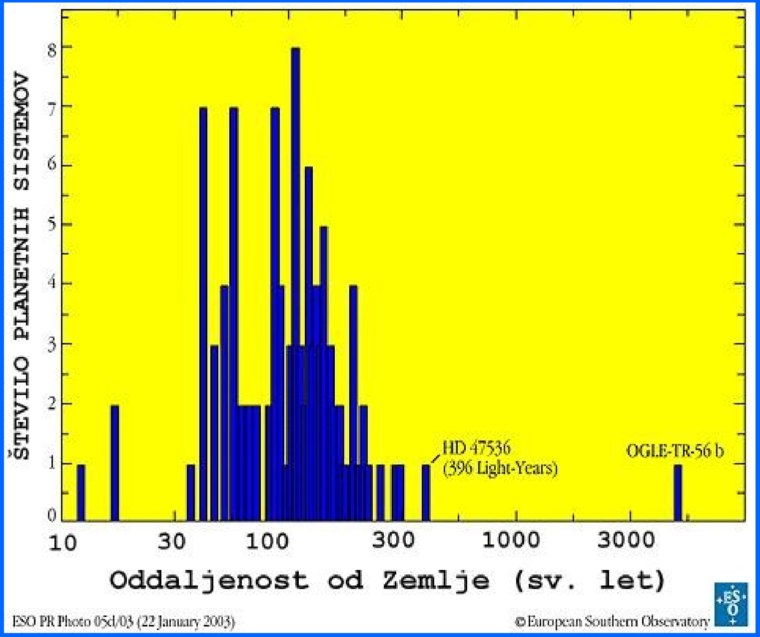
Planet prekrije del ploskve zvezde.

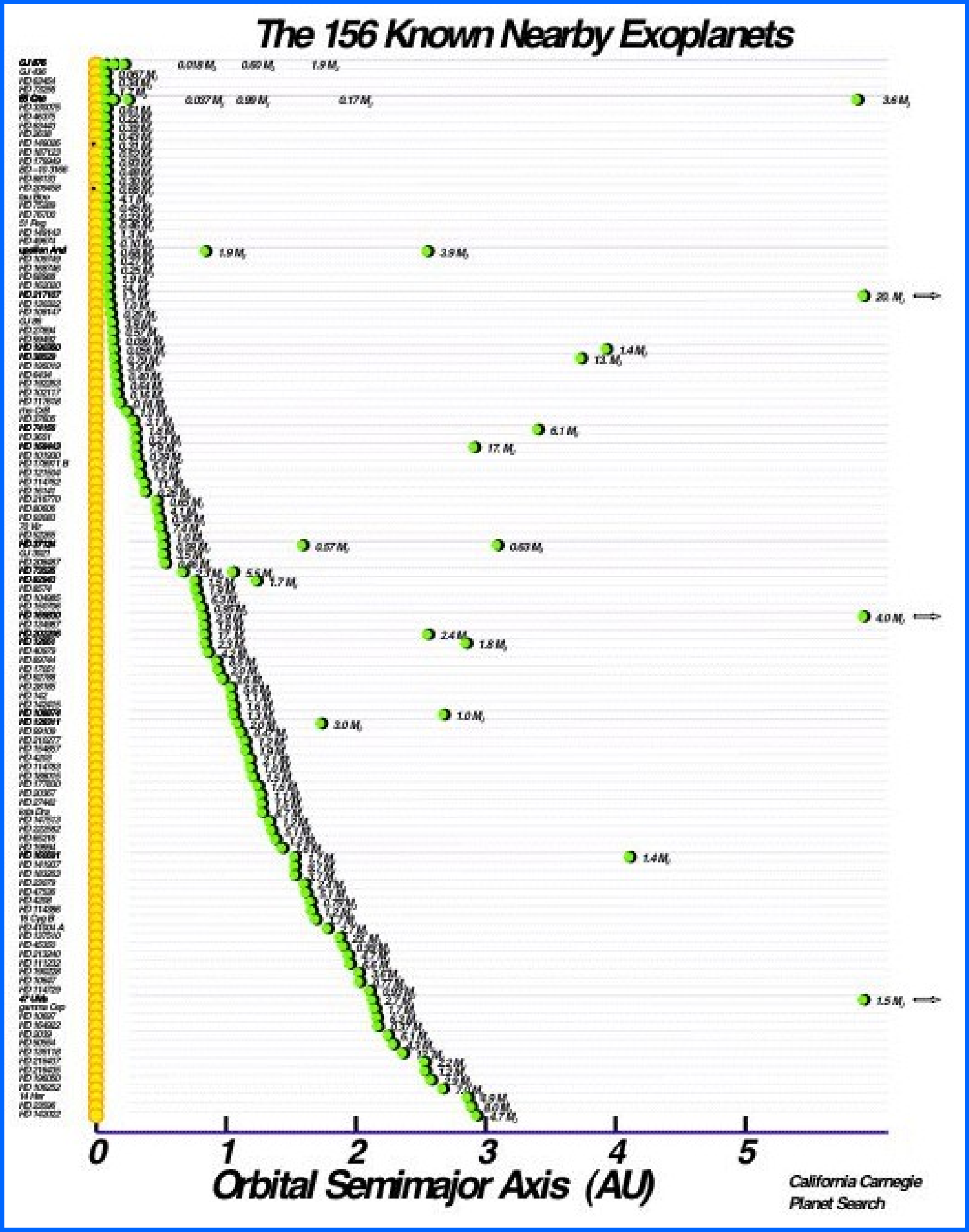


Planeti zunaj Osončja

Stanje 2. oktobra 2005:

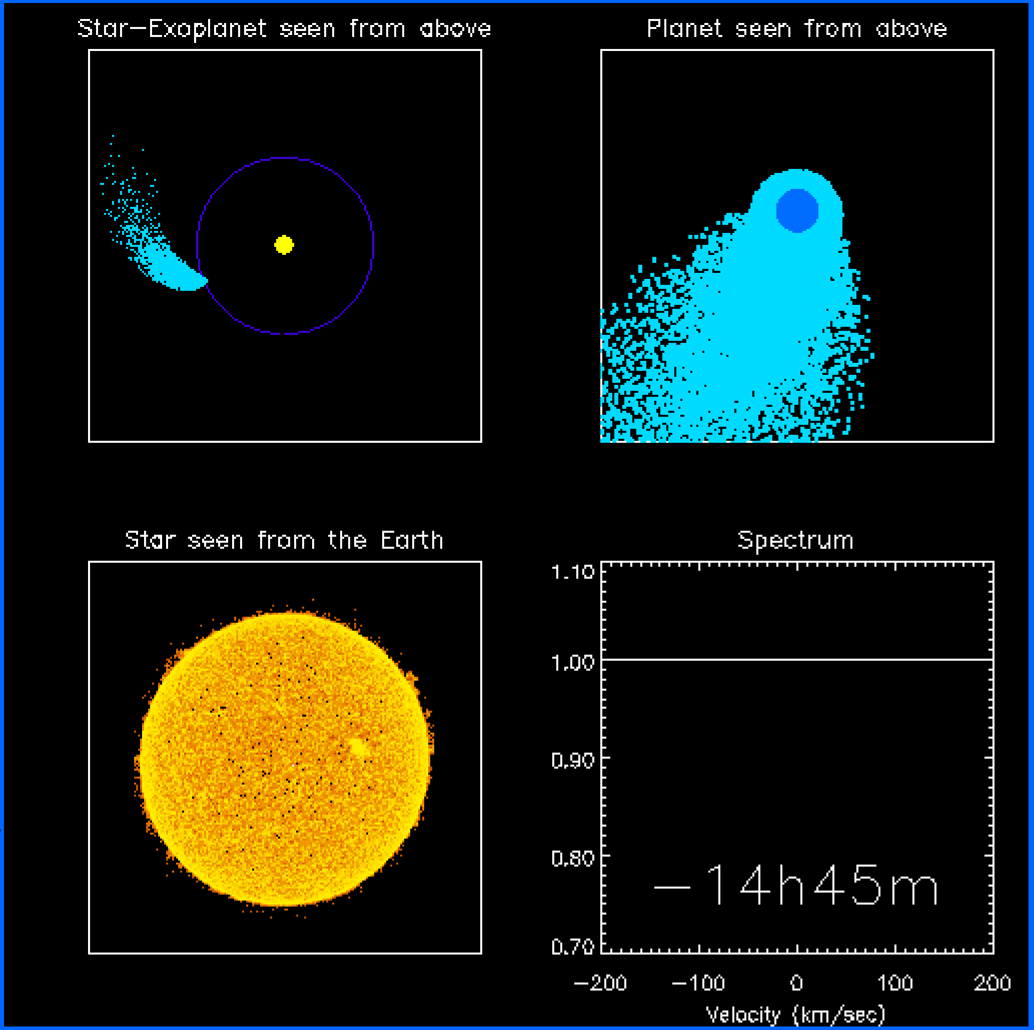
- 144 zvezd podobnih Soncu je obdanih s planeti,
- 168 znanih planetov zunaj Osončja.





Planet ob zvezdi HD 209458 ima atmosfero

Ob prehodu planeta preko zvezdine ploskvice opazimo poleg geometrijskega pokritja dela zvezde še dodatno absorpcijo zaradi natrija, vodika in ogljika v planetovi atmosferi.



Oddaljenost od Zemlje: 160 sv.l.
masa planeta: 0.7 $M_{Jupiter}$
polmer planeta: 1.5 $R_{Jupiter}$
planet izgublja: ~10^7 kg/s