

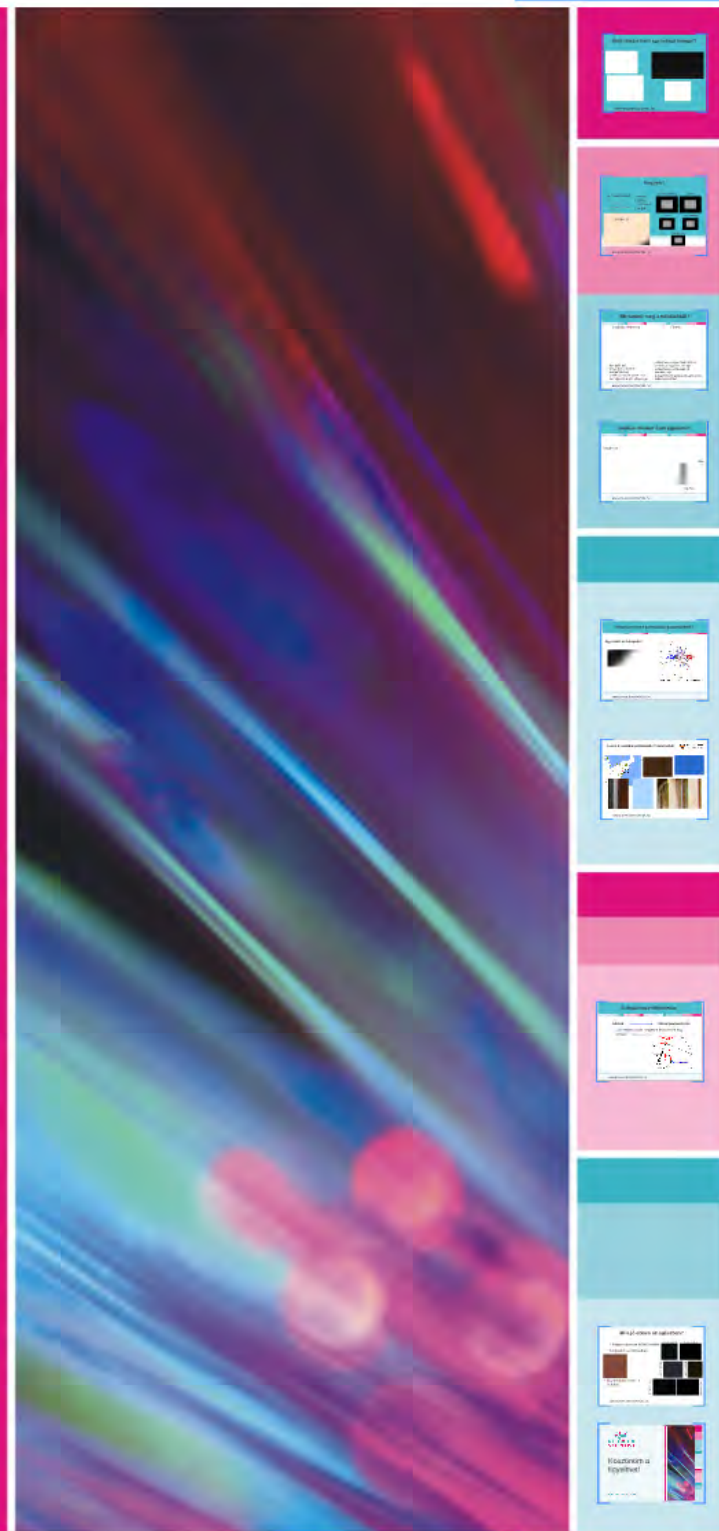


Hogyan lehet fénnyel tömeget mérni?

Kovács Tamás
ELTE, Elm. Fiz. Tsz.

Ciszterci Rend Nagy Lajos Gimnáziuma
Pécs, 2015. november 11.

www.meetthescientist.hu





Hogyan lehet fénnyel tömeget mérni?

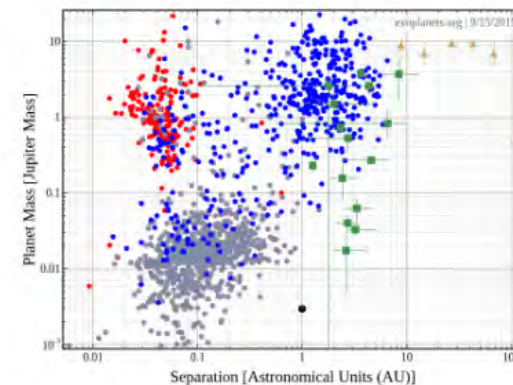
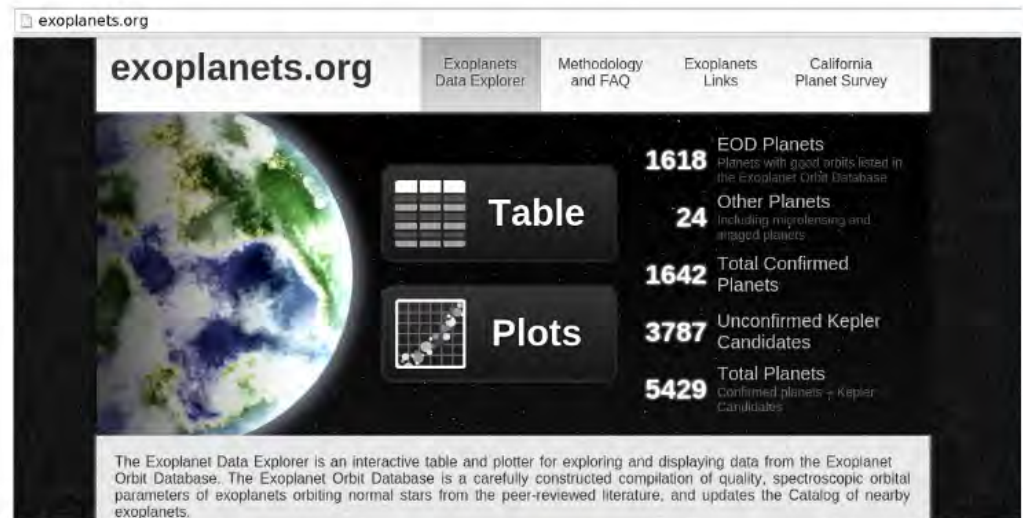
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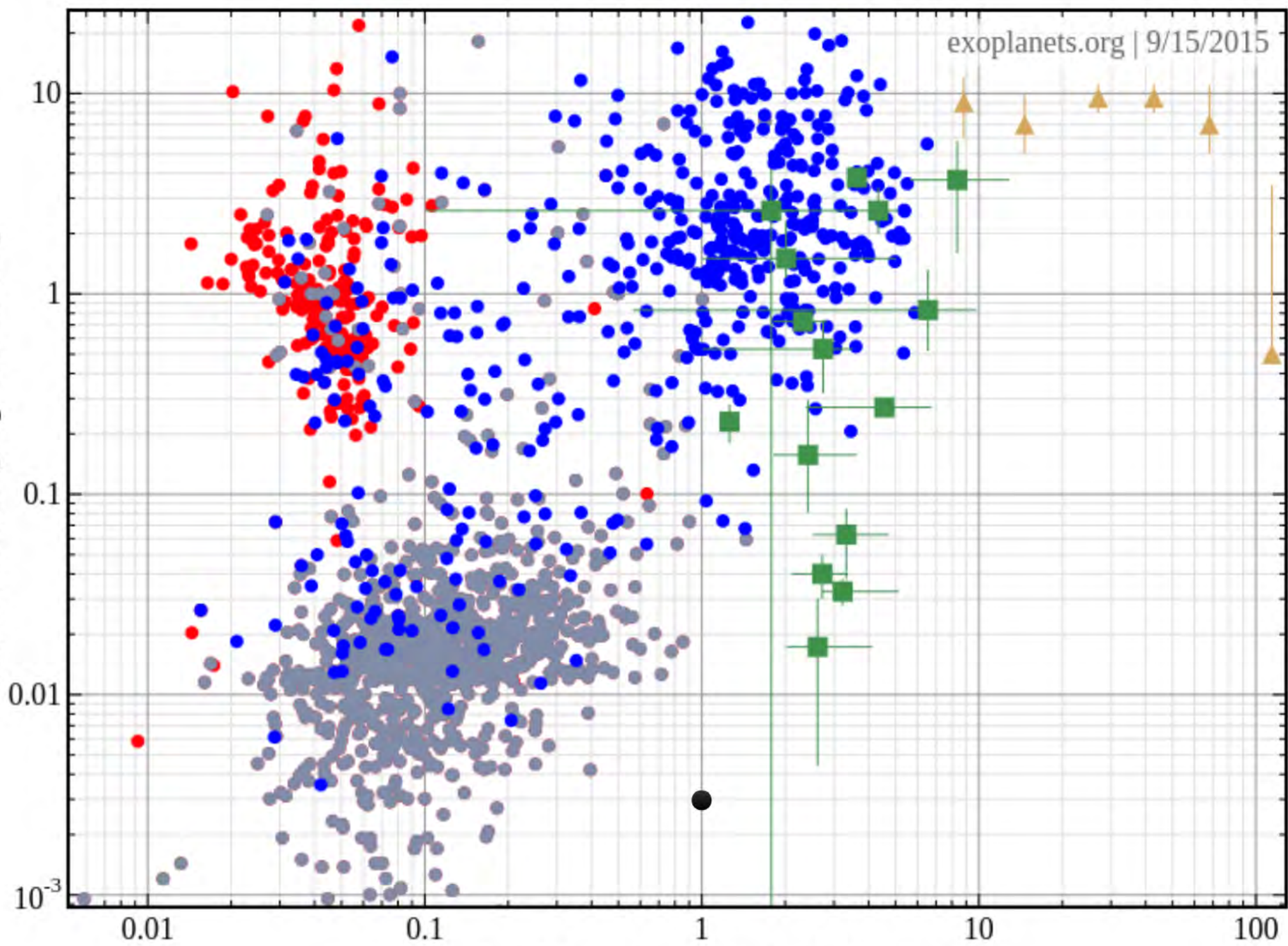


Miért akarjuk tudni egy bolygó tömegét?



Planet Mass [Jupiter Mass]

exoplanets.org | 9/15/2015



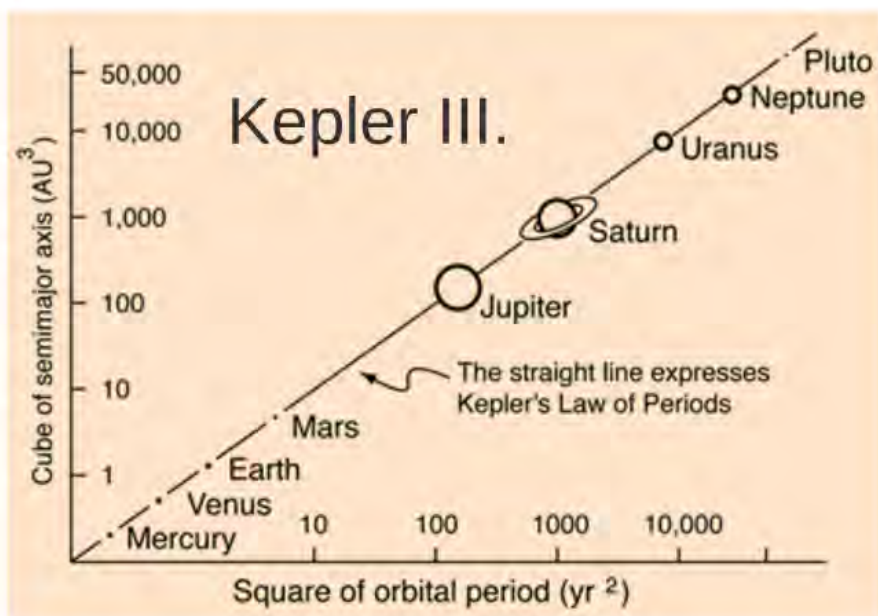
Separation [Astronomical Units (AU)]

Hogyan?

Égi mechanika:

- matek
- fizika
- számtech
- angol

Érdi Bálint:
Keplertől Keplerig
(2014)



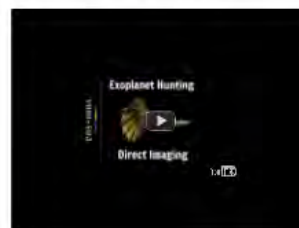
Radialis sebesség



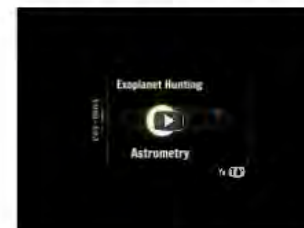
Fedés



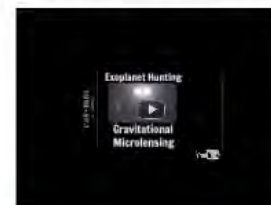
Direkt



Asztrometria



Mikrolencse



cos-mos



Exoplanet Hunting



Transit Method

You Tube

cos-mos



Exoplanet Hunting

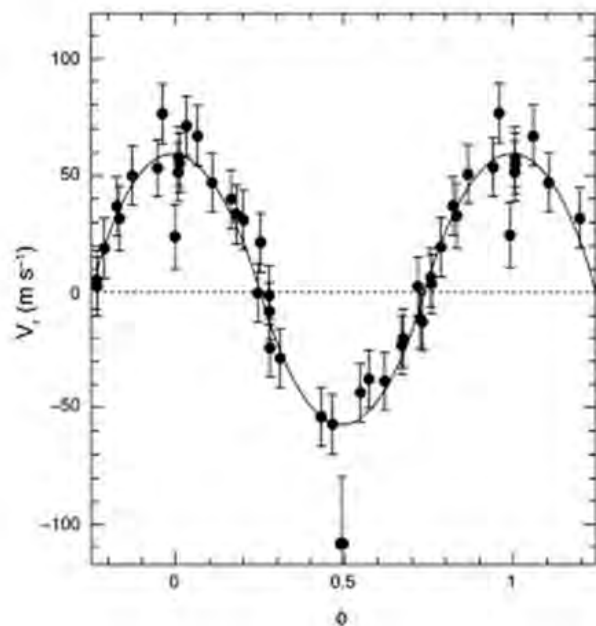


Radial Velocity

YouTube

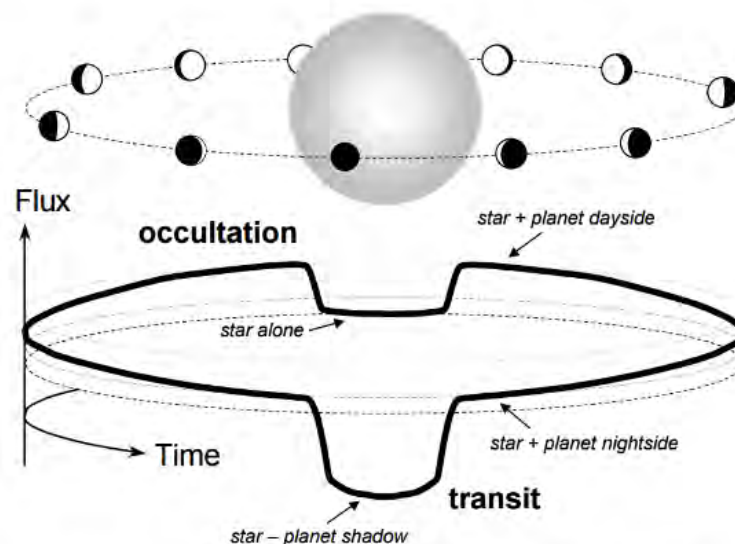
Mit tudunk meg a mérésekből?

Radiális sebesség



- keringési idő
- pálya alakja, mérete
- (vetített) tömeg
- a csillag forgástengelye és a keringés síkjának hajlásszöge

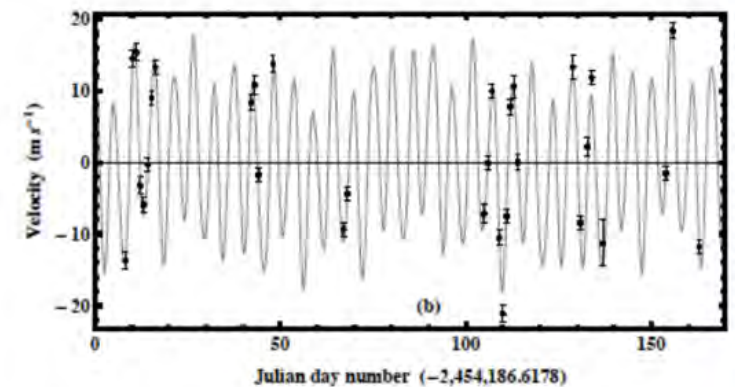
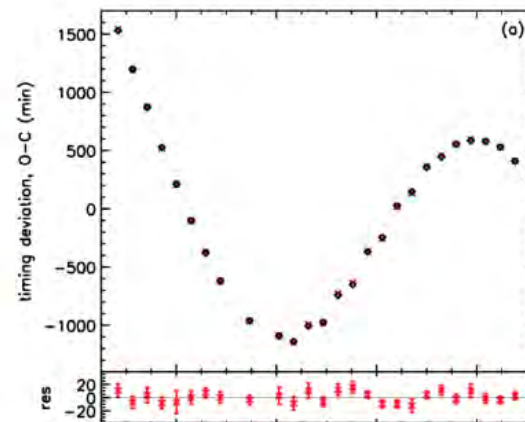
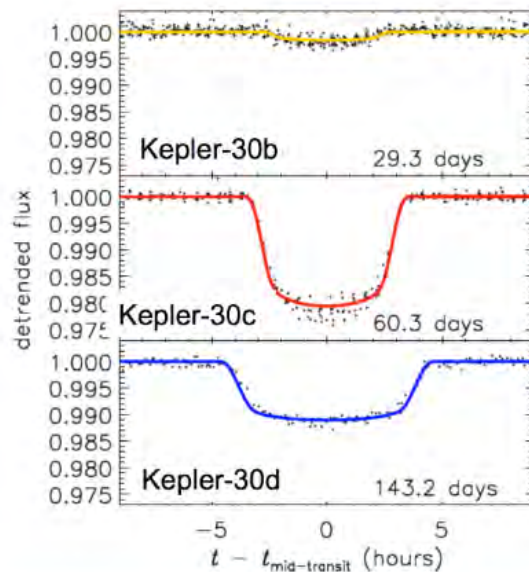
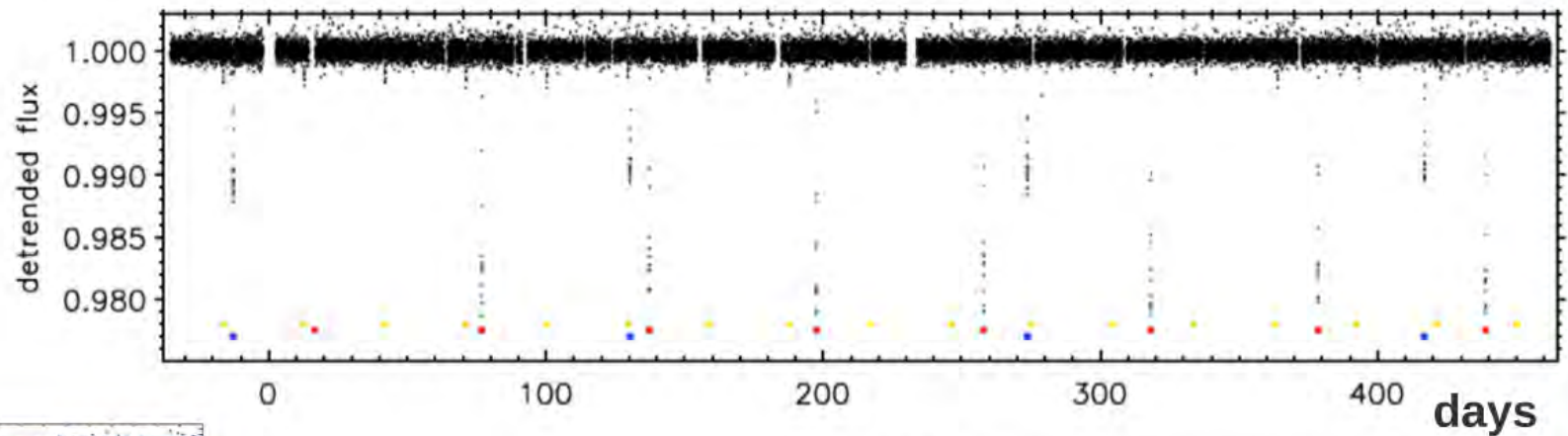
Fedés



- csillag/bolygó sugarának aránya
- a rendszer együttes tömege
- csillag/bolygó sűrűségének kombinációja
- bolygó felszíni gravitációs gyorsulása
- légkör összetétel

Valóban minden ilyen egyszerű?

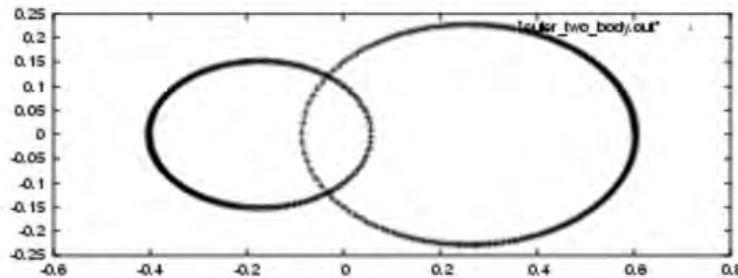
Kepler-30



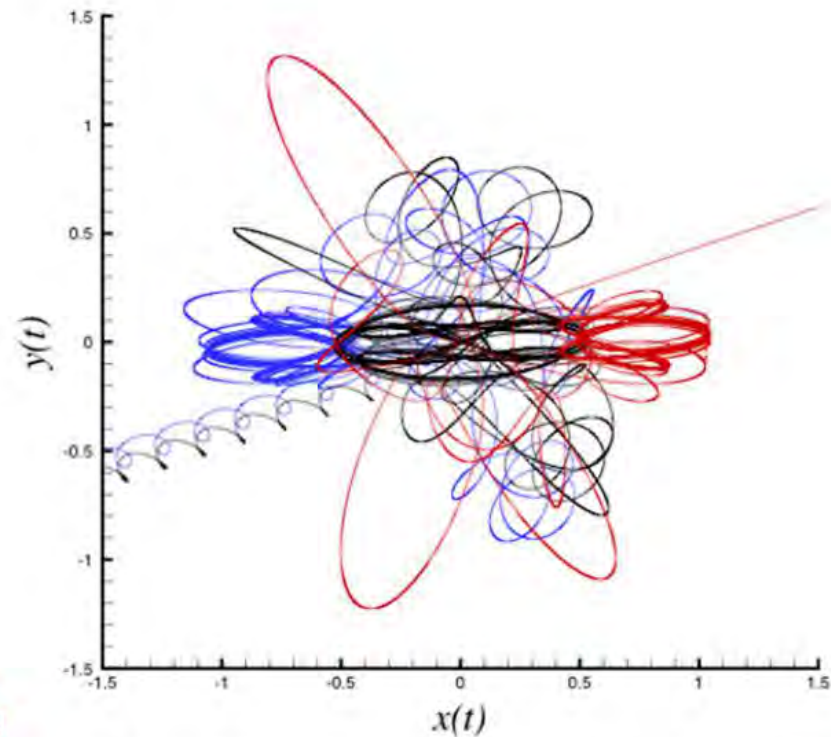
GL-581

Minek az egyre pontosabb paraméterek?

Egyszerű és bonyolult



$$ma = -G \frac{Mm}{r^2} + \mathcal{R}$$



Orbits of three-body in case of BUTTERFLY-I

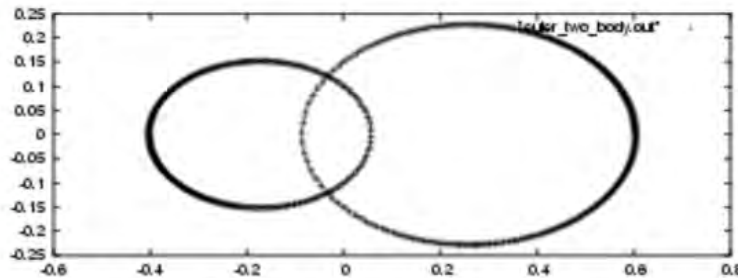
$$\begin{aligned}
& \ddot{\theta} \left\{ \left[m\mathcal{R}^2 + \frac{1}{3}\alpha(7K_2 + 8G_2) \right] - 7\alpha K_2 x_{n'}''^2 \right\} + \ddot{\phi} \left\{ -7\alpha K_2 a_{31}'' x_{n'}'' \right\} + \ddot{\psi} \left\{ -7\alpha K_2 x_{z'}'' x_{n'}'' \right\} + \dot{\psi} \dot{\phi} \sin \theta \left\{ \left[m\mathcal{R}^2 + \frac{1}{3}\alpha(7K_2 + 8G_2) \right] - 7\alpha K_2 x_{n'}''^2 \right\} \\
& + \dot{\theta}(\dot{\phi} - \dot{\psi} \cos \theta) \left\{ -7\alpha K_2 x_{z \times n'}'' x_{n'}'' \right\} - \dot{\theta} \dot{\psi} \sin \theta \left\{ -7\alpha K_2 a_{31}'' x_{n'}'' \right\} = \alpha J_{n'},
\end{aligned} \tag{B.11}$$

$$\begin{aligned}
& \ddot{\theta} \left\{ -7\alpha K_2 x_{n'}'' x_{z'}'' \right\} + \ddot{\phi} \left\{ \left[m\mathcal{R}^2 + \frac{1}{3}\alpha(7K_2 - 16G_2) a_{33}' \right] - 7\alpha K_2 a_{31}'' x_{z'}'' \right\} + \ddot{\psi} \left\{ \left[m\mathcal{R}^2 + \frac{1}{3}\alpha(7K_2 - 16G_2) \right] - 7\alpha K_2 x_{z'}''^2 \right\} \\
& + \dot{\psi} \dot{\phi} \sin \theta \left\{ -7\alpha K_2 x_{n'}'' x_{z'}'' \right\} + \dot{\theta}(\dot{\phi} - \dot{\psi} \cos \theta) \left\{ -7\alpha K_2 x_{z \times n'}'' x_{z'}'' - \left[m\mathcal{R}^2 + \frac{1}{3}\alpha(7K_2 - 16G_2) \right] \sin \theta \right\} \\
& - \dot{\theta} \dot{\psi} \sin \theta \left\{ \left[m\mathcal{R}^2 + \frac{1}{3}\alpha(7K_2 - 16G_2) a_{33}' \right] - 7\alpha K_2 a_{31}'' x_{z'}'' \right\} = \alpha J_{z'},
\end{aligned} \tag{B.12}$$

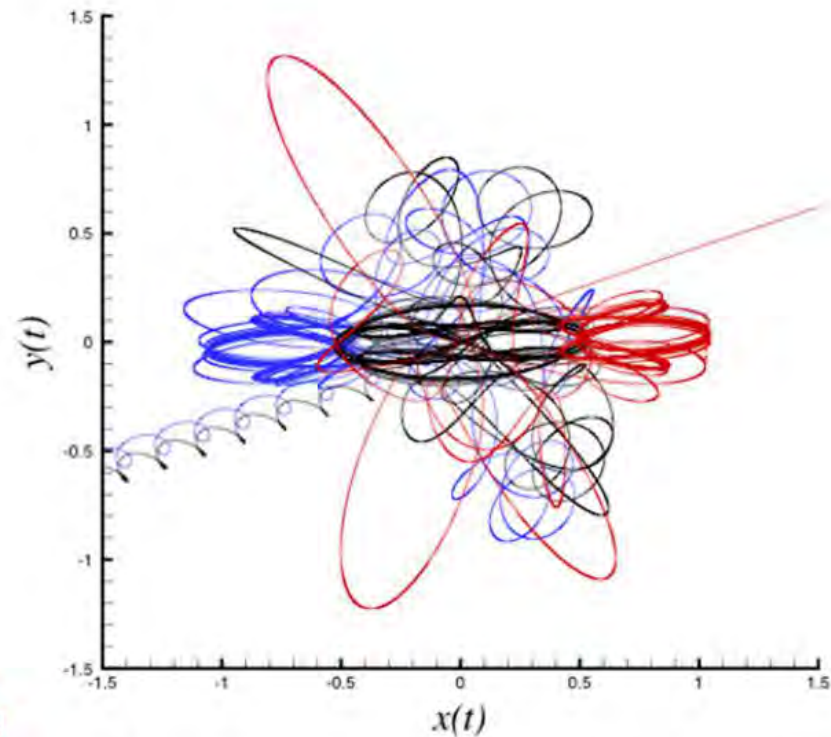
$$\begin{aligned}
& \ddot{\theta} \left\{ -7\alpha K_2 x_{n'}'' a_{31}'' \right\} + \ddot{\phi} \left\{ m\mathcal{R}^2 + \frac{1}{3}\alpha(7K_2 + 8G_2) - 7\alpha K_2 a_{31}''^2 - 8\alpha G_2 a_{33}'^2 \right\} \\
& + \ddot{\psi} \left\{ \left[m\mathcal{R}^2 + \frac{1}{3}\alpha(7K_2 - 16G_2) \right] a_{33}' - 7\alpha K_2 x_{z'}'' a_{31}'' \right\} + \dot{\psi} \dot{\phi} \sin \theta \left\{ -7\alpha K_2 x_{n'}'' a_{31}'' \right\} + \dot{\theta}(\dot{\phi} - \dot{\psi} \cos \theta) \left\{ -7\alpha K_2 x_{z \times n'}'' a_{31}'' \right. \\
& \left. + 8\alpha G_2 a_{33}' \sin \theta \right\} - \dot{\psi} \dot{\theta} \sin \theta \left\{ \left[m\mathcal{R}^2 + \frac{1}{3}\alpha(7K_2 + 8G_2) \right] - 7\alpha K_2 a_{31}''^2 - 8\alpha G_2 a_{33}'^2 \right\} = \alpha J_z.
\end{aligned} \tag{B.13}$$

Minek az egyre pontosabb paraméterek?

Egyszerű és bonyolult

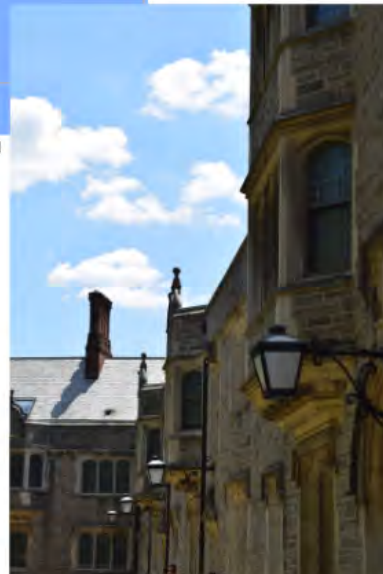


$$ma = -G \frac{Mm}{r^2} + \mathcal{R}$$



Orbits of three-body in case of BUTTERFLY-I

Inverz dinamikai problémák Princetontól



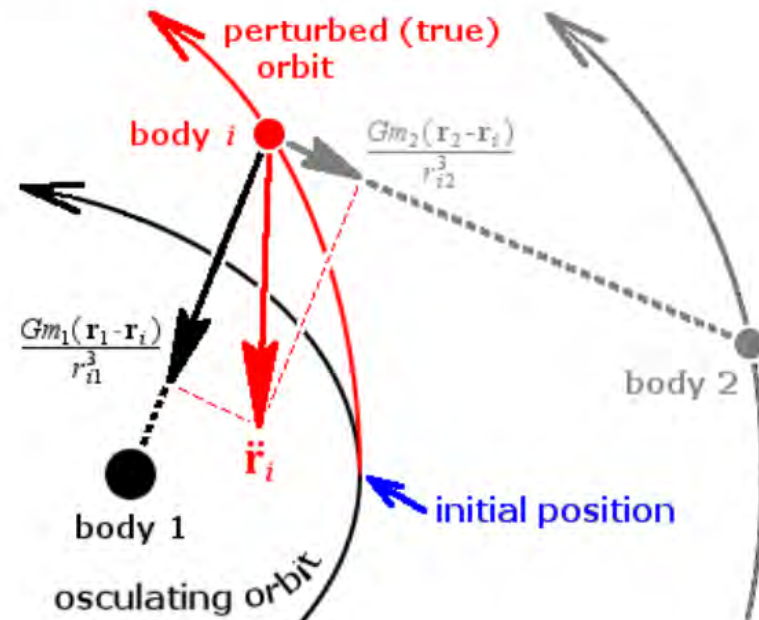
A Neptunusz felfedezése

Adatok



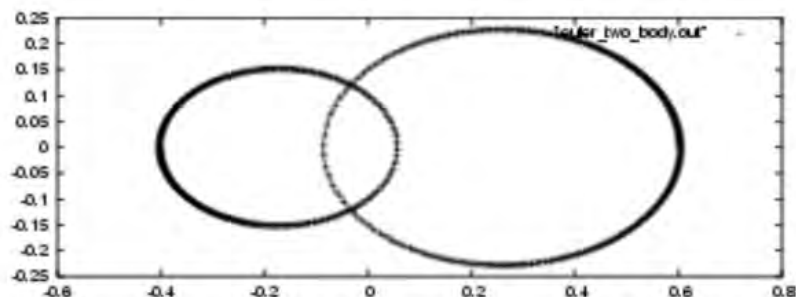
Modellparaméterek

„Le Verrier a tolla hegyével fedezett fel egy bolygót.” (Francois Arago, 1846)

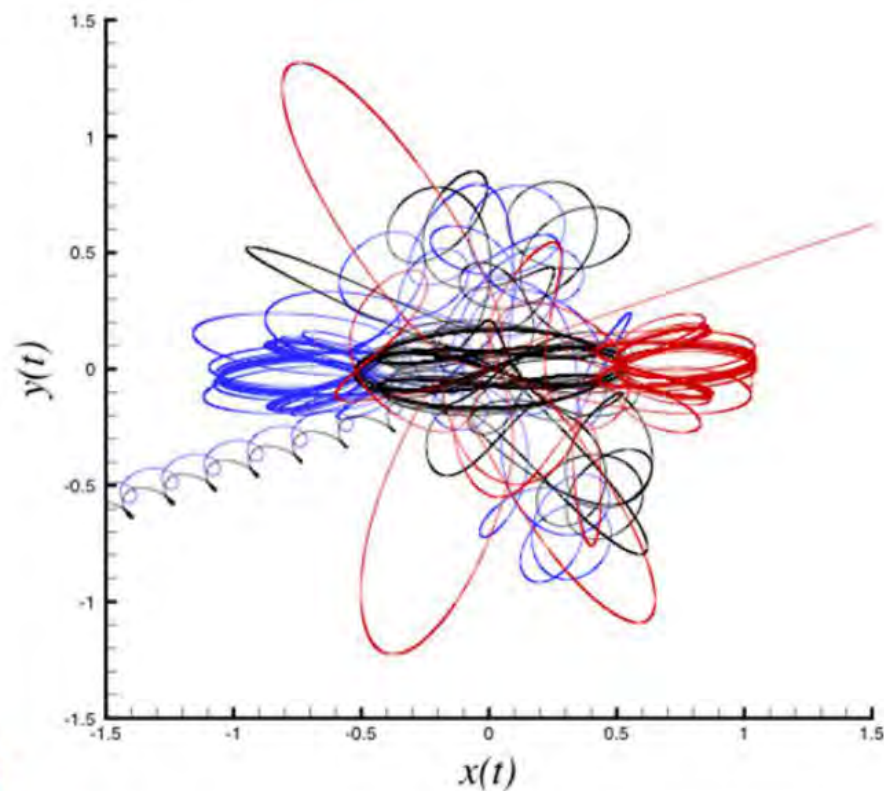


Minek az egyre pontosabb paraméterek?

Egyszerű és bonyolult



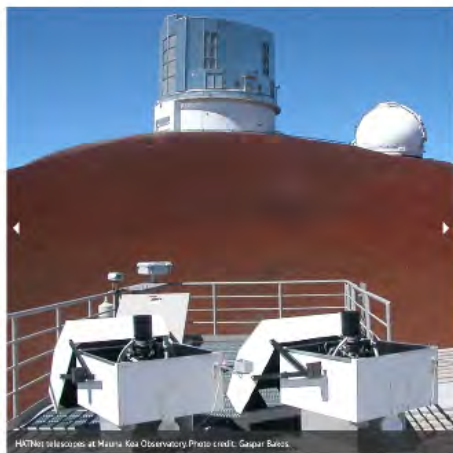
$$ma = -G \frac{Mm}{r^2} + \mathcal{R}$$



Orbits of three-body in case of BUTTERFLY-I

Mi a jó ebben az egészben?

- Nagyon gyorsan fejlődő terület
- Magyarok az élvonalban



The HATNet Exoplanet Survey



The Hungarian-made Automated Telescope Network (HATNet) Exoplanet Survey is a geographically distributed network of 7 small telescopes optimized for detecting transiting exoplanets. Since first light in 2003, we have discovered 35 exoplanets to date. This website shows how the project, and presents all data used to detect and characterize the transiting exoplanets discovered by the HATNet survey. Use the links on the sidebar to learn more. If you need help, please let us know!

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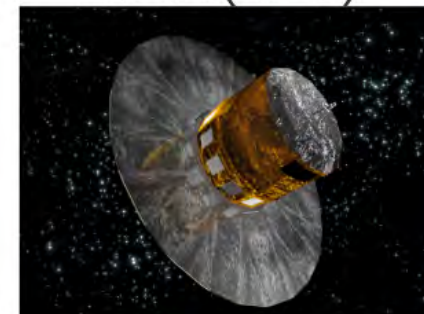
HAT Surveys - HATNet - HATSouth

Pages:
Home
Operations
Contact the team
Rules:
All discovered planets
HATNet light curves
Planet follow-up data

TESS (2017)



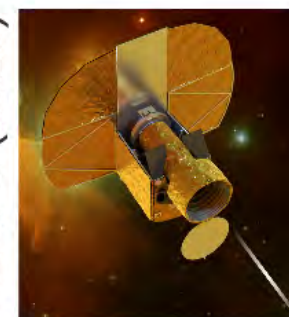
GAIA (2015)



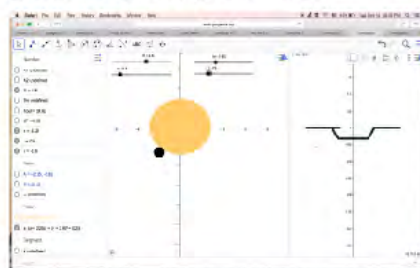
JWST (2018)



PLATO (2023)



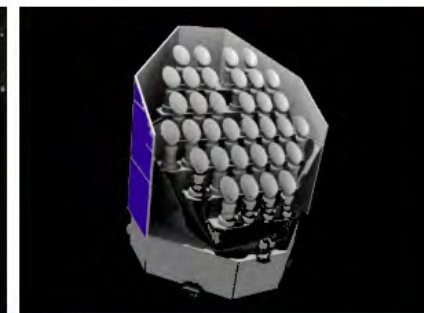
- Középiskolás fokon is érdekes



WFIRST (2023)



CHEOPS (2017)





○ A1 undefined

○ A2 undefined

 **R = 2.8**

○ Tin undefined

○ Tout = 24.62

○ $dF = 0.03$

● $h = -2.25$

 $r = 0.5$

 $v = -2.6$

- Point

○ $A = (-2.25, -2.6)$

○ $B = (0, 0)$

○ C undefined

Conic

$$C: x^2 + y^2 = 7.84$$

● e: $(x + 2.25)^2 + (y + 2.6)^2 = 0.25$

Segment

○ a undefined



10



Köszönöm a
figyelmet!

www.meetthescientist.hu





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