Sayari na Sayari-nje

Planets and exoplanets

Rosa M. Ros, Hans Deeg, Ricardo Moreno

International Astronomical Union

Muungano wa WanaAstronomia wa Kimataifa

Technical University of Catalonia, Spain

Chuo Kikuu cha Kitechnologia ya Catalonia, Hispania

Canarian Astrophysical Institute, Spain

Ctaasisi ya Astofizikia ya Kanari, Hispania

Colegio Retamar de Madrid, Spain

Chuo cha Retamar, Madrid, Hispania

Malengo

Goals

- **Kuelewa maana za viwango vya tarkimu zinazopatikana katika jedwali za data za sayari za Mfumo wa Jua**
- Understand the meaning of the numerical values found in the data tables of the Solar System planets
- **Kufahamu dalili maalum za sayari zilizo katika mifumo mbali na mfumo wa Jua**
- Understand the main characteristics of extra-solar planetary systems

Mfumo wa jua
Solar system

Tunatafuta mifano ambayo hutoa habari, sio tu sanaa na ufundi.

We look for models that provide information,

not only arts and crafts.

Kulingana na yaliyomo
According to the content

Tunataka miundo yenye maudhui ya kisayansi na yale ambayo yanaonyesha baadhi ya vipengele madhubuti

We want models with scientific content and those that display some concrete points

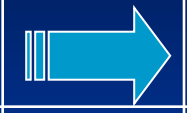
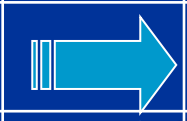
Shughuli 1: Umbali kutoka Jua

Activity 1: Distances from the Sun

Zebaki Mercury	57 900 000 km	6 cm	0.4 AU
Zuhura Venus	108 300 000 km	11 cm	0.7 AU
Dunia Earth	149 700 000 km	15 cm	1.0 AU
Mirihi Mars	228 100 000 km	23 cm	1.5 AU
Jupita Jupiter	778 700 000 km	78 cm	5.2 AU
Zohali Saturn	1 430 100 000 km	143 cm	9.6 AU
Uranus Uranus	2 876 500 000 km	288 cm	19.2 AU
Neptun Neptune	4 506 600 000 km	450 cm	30.1 AU

Shughuli 2: Mfano wa Vipenyo

Activity 2: Model of Diameters

Jua Sun	1 392 000 km		139.0 cm
Zuhura Venus	4 878 km		0.5 cm
Dunia Earth	12 180 km		1.2 cm
Mirihi Mars	12 756 km		1.3 cm
Jupita Jupiter	6 760 km		0.7 cm
Zohali Saturn	142 800 km		14.3 cm
Uranus Uranus	120 000 km		12.0 cm
Neptun Neptune	50 000 km		5.0 cm
Zuhura Venus	45 000 km		4.5 cm

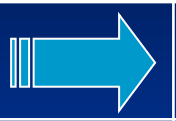
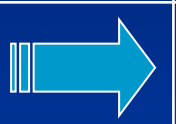
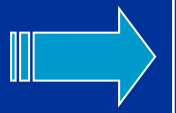
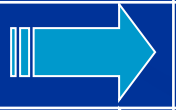
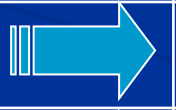
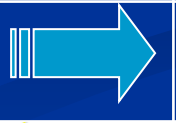
Shughuli 2: Mfano wa Vipenyo

Activity 2: Model of Diameters

T-shati yenye kipenyo cha sayari kwa kiwango

T-shirt with the diameters of the planets to scale

Shughuli ya 3: Vipenyo na umbali kutoka kwa Jua
Activity 3: Diameters and distances from the Sun

Jua Sun	1 392 000 km			25.0 cm	
Zebaki Mercury	4 878 km	57 900 000 km		0.1 cm	10 m
Zuhura Venus	12 180 km	108 300 000 km		0.2 cm	19 m
Dunia Earth	12 756 km	149 700 000 km		0.2 cm	27 m
Mirihi Mars	6 760 km	228 100 000 km		0.1 cm	41 m
Jupita Jupiter	142 800 km	778 700 000 km		2.5 cm	140 m
Zohali Saturn	120 000 km	1 430 100 000 km		2.0 cm	250 m
Uranus Uranus	50 000 km	2 876 500 000 km		1.0 cm	500 m
Neptun Neptune	45 000 km	4 506 600 000 km		1.0 cm	m

Kawaida yadi ya shule hufikia Mirihi pekee

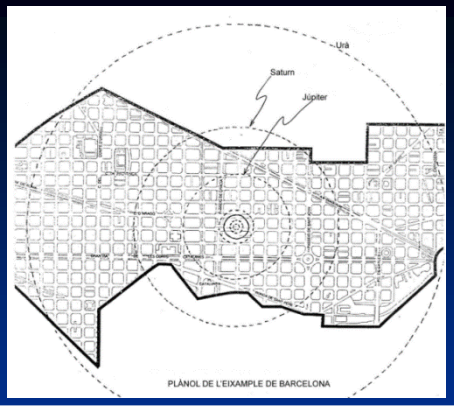
Usually a school yard only reaches out to Mars

Shughuli ya 3: Mfano wa vipenyo na umbali katika uwanja wa michezo ...

Activity 3: Model of diameters and distances in the playground ...

Shughuli ya 4: Mwanamitindo mjini (Barcelona)

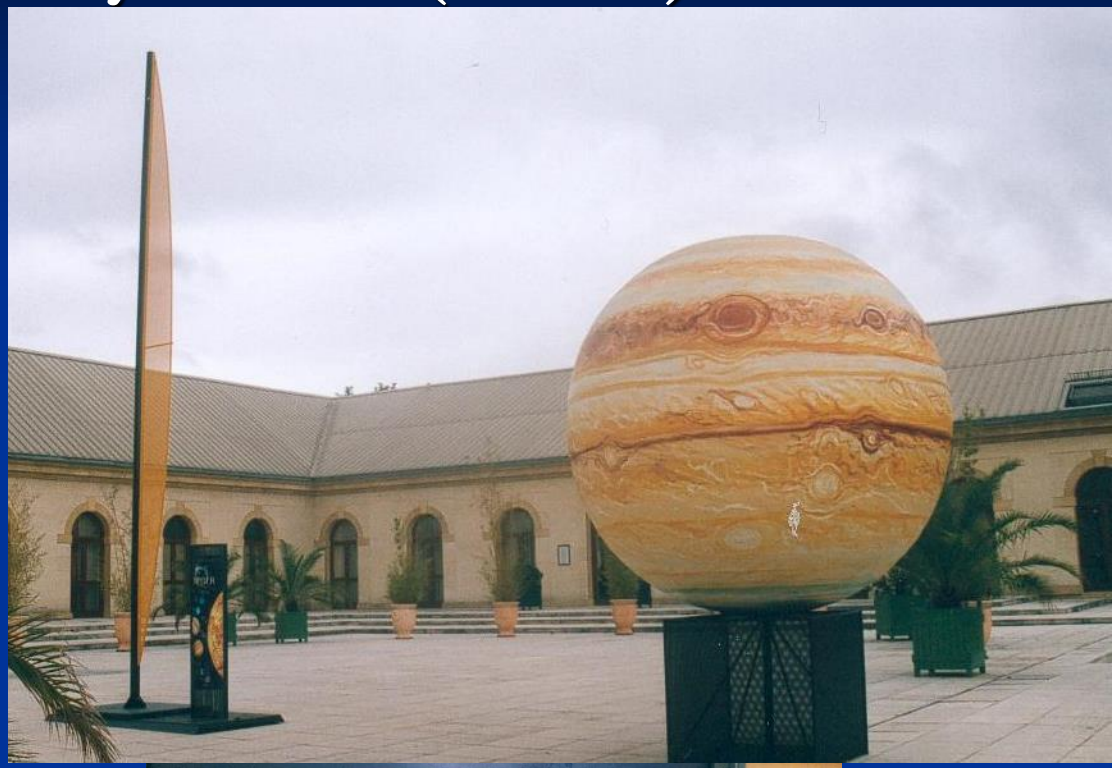
Activity 4: Model in the city *(Barcelona)*



Jua Sun	**Kuosha Mashine** Washing machine	*Puerta Instituto*
Zebaki Mercury	**Yai ya caviar** Caviar egg	*Puerta Hotel Diplomatic*
Zuhura Venus	**Mbaazi** Pea	*Pasaje Méndez Vigo*
Dunia Earth	**Mbaazi** Pea	*Entre Méndez Vigo y Bruc*
Mirihi Mars	**Nafaka ya pilipili** Pepper grain	*Paseo de Gracia*
Jupita Jupiter	**Machungwa** Orange	*Calle Balmes*
Zohali Saturn	**Tangerine** Tangerine	*Pasaje Valeri Serra*
Uranus Uranus	**Chestnut** Chestnut	*Calle Entenz*
Neptun Neptune	**Chestnut** Chestnut	*Estación de Sans*

Mfano katika mji wa Metz (Ufaransa)

Model in the city of Metz (France)



Shughuli 5: Mfano wa nyakati

Activity 5: Model of times

- c = 300 000 km/s

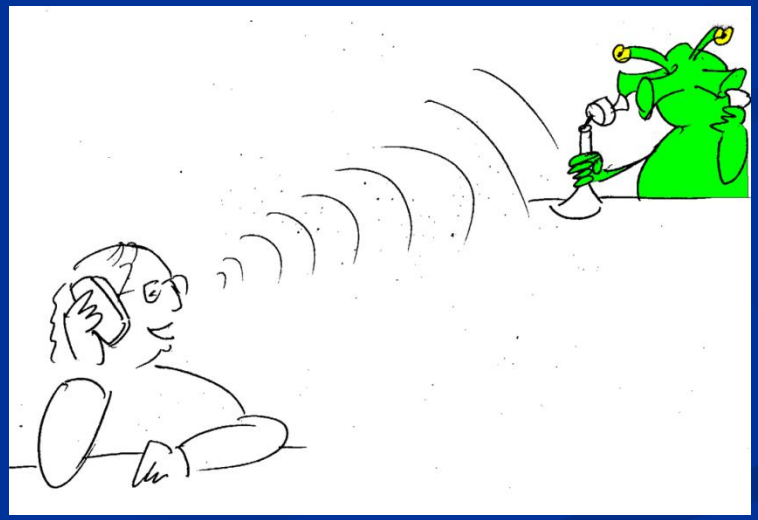
Wakati inachukua mwanga kutoka Duniani hadi Mwezi ni:

The time it takes light to go from Earth to Moon is:

t = distance EM / c = 384 000 km / 300 000 = 1.3 s

Jinsi gani mazungumzo kati ya sayari kwa "video" kuwa?

How would a conversation between planets by “video” be?



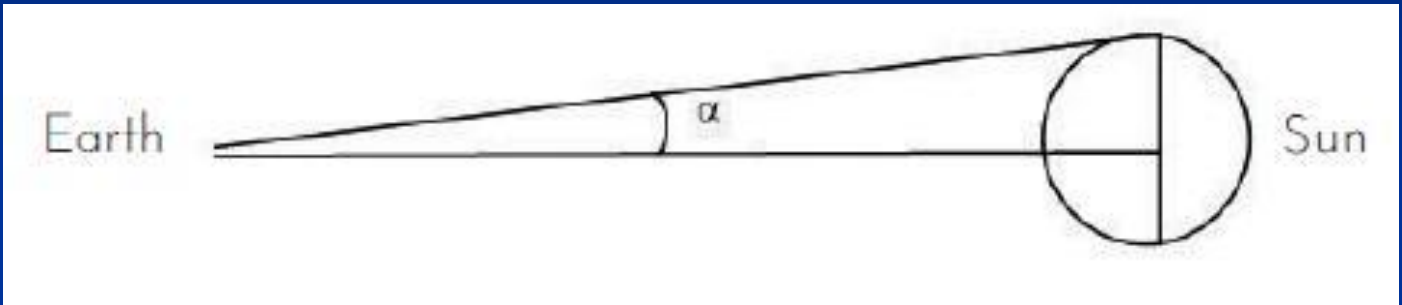
Mwanga wa jua huchukua hadi kufikia ...

Sunlight takes to get to ...

Zebaki Mercury	57 900 000 km	→	3.3 minutes
Zuhura Venus	108 300 000 km	→	6.0 minutes
Dunia Earth	149 700 000 km	→	8.3 minutes
Mirihi Mars	228 100 000 km	→	12.7 minutes
Jupita Jupiter	778 700 000 km	→	43.2 minutes
Zohali Saturn	1 430 100 000 km	→	1.32 hours
Uranus Uranus	2 876 500 000 km	→	2.66 hours
Neptun Neptune	4 506 600 000 km	→	4.16 hours

Shughuli ya 6: Jua linavyoonekana kutoka kwenye sayari

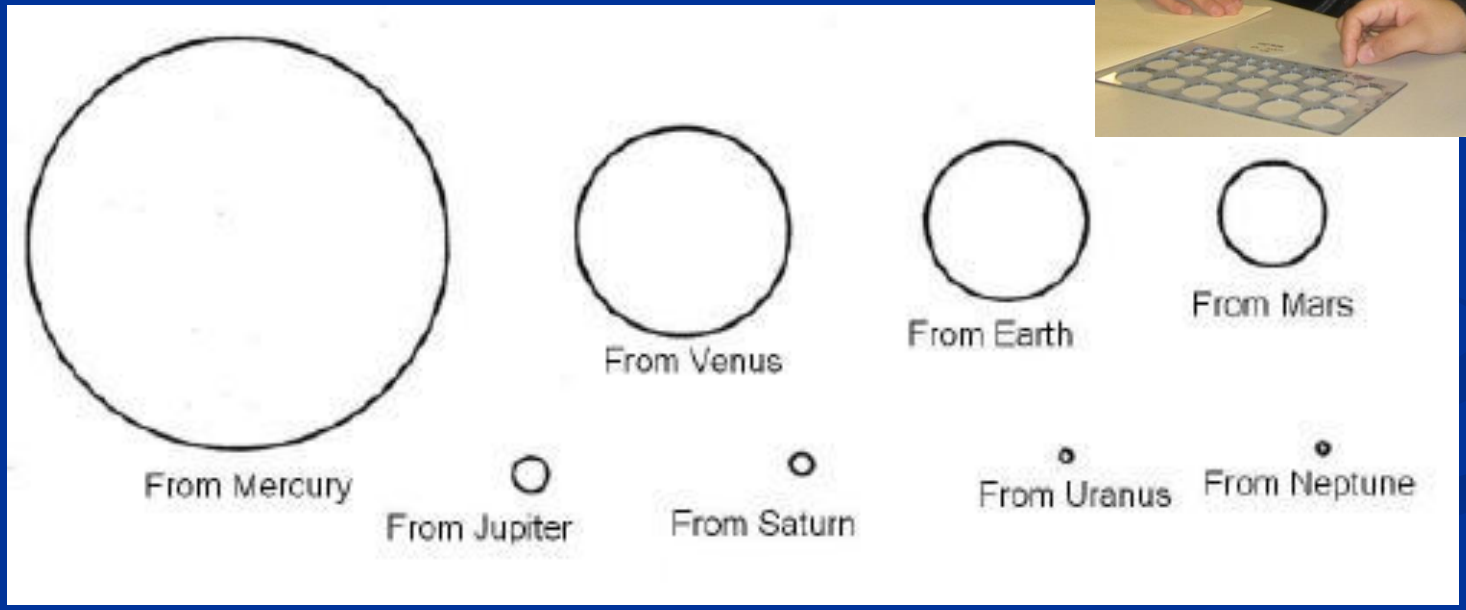
Activity 6: The Sun as seen from the planets



- $\alpha = \tan \alpha =$ radius **Jua** Sun /**umbali wa jua** distance to Sun $= 700\,000/150\,000\,000 = 0.0045$ radian $= 0.255^{\circ}$
- **Kutoka kwa Dunia, Jua hupima $2\alpha = 0.51^{\circ}$**
- From the Earth, the Sun measures $2\alpha = 0.51^{\circ}$

Shughuli ya 6: Jua linavyoonekana kutoka kwenye sayari

Activity 6: The Sun as seen from planets



Shughuli 7: Mfano wa msongamano

Activity 7: Model of densities

Jua Sun	1.41 g/cm^3	→	**Salfa** Sulfur (1.1-2.2)
Zebaki Mercury	5.41 g/cm^3	→	**Pyrite** Pyrite (5.2)
Zuhura Venus	5.25 g/cm^3	→	**Pyrite** Pyrite (5.2)
Dunia Earth	5.52 g/cm^3	→	**Pyrite** Pyrite (5.2)
Mirihi Mars	3.90 g/cm^3	→	Blende (4.0)
Jupita Jupiter	1.33 g/cm^3	→	**Salfa** Sulfur (1.1-2.2)
Zohali Saturn	0.71 g/cm^3	→	**Mbao ya pine** Pine wood (0.55)
Uranus Uranus	1.30 g/cm^3	→	**Salfa** Sulfur (1.1-2.2)
Neptun Neptune	1.70 g/cm^3	→	**Udongo** Clay (1.8-2.5)

Shughuli ya 8: Mfano wa Kutandaza

Activity 8: Flattening Model

- Kata vipande vya kadibodi 35 x 1 cm
- Ambatanisha kwa fimbo ya silinda yenye urefu wa cm 50 na kipenyo cha 1 cm. Acha mwisho wa chini huru ili iweze kusonga kando ya fimbo.
- Zungusha kijiti kati ya mikono yako na mizunguko ya haraka katika mwelekeo mmoja na mwingine. Nguvu ya centrifugal huharibu bendi za kadibodi kama sayari zinavyoharibika.

- Cut cardboard strips of 35 x 1 cm.
- Attach them to a cylindrical stick 50 cm long and 1 cm in diameter. Leave the lower end loose so that it can move along the stick.
- Rotate the stick in between your hands with quick rotations in one direction and the other. The centrifugal force deforms the cardboard bands as planets are deformed.

Shughuli ya 8: Kuweka gorofa

Activity 8: Flattening

Sayari Planets	(Ikweta radius-polar radius)/ eneo la ikweta (equatorial radius-polar radius)/ equatorial radius
Zebaki Mercury	0.0
Zuhura Venus	0.0
Dunia Earth	0.0034
Mirihi Mars	0.005
Jupita Jupiter	0.064
Zohali Saturn	0.108
Uranus Uranus	0.03
Neptun Neptune	0.03

Shughuli ya 9: Muundo wa Vipindi vya Orbital

Activity 9: Orbital Periods model

- Ambatanisha nut kwa mwisho mmoja wa kamba na ushikilie kamba kinyume chake. Pindua kamba juu ya kichwa chako.
- Unapotoa kamba zaidi, inachukua muda mrefu kukamilisha kipindi cha obiti
- Ikiwa utaondoa baadhi ya kamba, inachukua muda kidogo

- Attach a nut to one end of a rope and hold the rope opposite to it. Turn the rope over your head.
- As you release more rope, it takes longer to complete an orbital period
- If you remove some of the rope, it takes less time

Shughuli ya 9: Data ya obiti ya Dunia

Activity 9: Earth orbital data

Kasi ya wastani ya obiti $v = 2\pi R / T$

Kwa Dunia:

$$v = 2\pi \times 150 \times 10^6 / 365$$

$$v = 2\,582\,100 \text{ km/day} = 107\,590 \text{ km/h} = 29.9 \text{ km/s}$$

(Kasi ya wastani ya obiti ya Jua kuzunguka kituo cha galaksi ni 220 km/s au 800 000 km/h.)

The average orbital velocity $v = 2\pi R / T$

For the Earth

$v = 2\pi \times 150 \times 10^6 / 365$

$v = 2\,582\,100$ km/day = 107 590 km/h = 29.9 km/s

(The average orbital speed of Sun around the galactic centre is 220 km/s or 800 000 km/h.)

Shughuli ya 9: Data ya Orbital

Activity 9: Orbital data

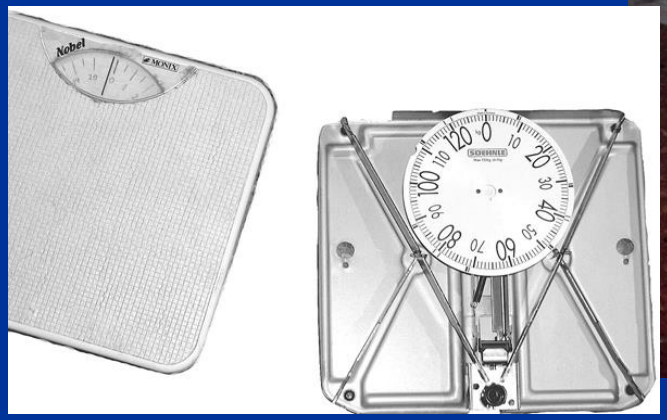
Sayari Planet	Kipindi cha Orbital (siku) Orbital period (days)	Umbali kutoka Jua (km) Distance from the Sun (km)	Kasi ya wastani ya obiti (km/s) Orbital average speed (km/s)	Kasi ya wastani ya obiti (km/h) Orbital average speed (km/h)
Zebaki **Mercury**	87.97	57.9×10^6	47.90	172 440
Zuhura **Venus**	224.70	108.3×10^6	35.02	126 072
Dunia **Earth**	365.26	149.7×10^6	29.78	107 208
Mirihi **Mars**	686.97	228.1×10^6	24.08	86 688
Jupita **Jupiter**	4331.57	778.7×10^6	13.07	47 052
Zohali **Saturn**	10759.22	$1\,430.1 \times 10^6$	9.69	34 884
Uranus **Uranus**	30.799.10	$2\,876.5 \times 10^6$	6.81	24 876
Neptun **Neptune**	60190.00	$4\,506.6 \times 10^6$	5.43	19 558

Shughuli ya 10: Mfano wa kuongeza kasi ya mvuto wa uso

Activity 10: Model of surface gravitational accelerations

- **Mvuto wa uso, $F = G\,M\,m/d^2$, na $m = 1$, $d = R$. Hivyo $g = G\,M / R^2$, ambapo $M = 4/3\,\pi\,R^3\,\rho$**
- **Kubadilisha: $g = 4/3\,\pi\,G\,R\,\rho$**

- Surface gravity, $F = G\,M\,m/d^2$, with $m = 1$, $d = R$. Thus $g = G\,M / R^2$, where $M = 4/3\,\pi\,R^3\,\rho$
- Replacing: $g = 4/3\,\pi\,G\,R\,\rho$



Shughuli 10: Kuongeza kasi ya mvuto kwenye uso

Activity 10: Surface gravitational accelerations

Sayari Planets	Radius ya ikweta Equat. Radius	Msongamano Density		Kuongeza kasi ya hesabu Calc. acc.	Kuongeza kasi ya kweli Real acceleration.	
Zebaki Mercury	2 439 km	5.4 g/cm^3		0.378	3.70 m/s^2	0.37
Zuhura Venus	6 052 km	5.3 g/cm^3		0.894	8.87 m/s^2	0.86
Dunia Earth	6 378 km	5.5 g/cm^3		1.000	9.80 m/s^2	1.00
Mirihi Mars	3 397 km	3.9 g/cm^3		0.379	3.71 m/s^2	0.38
Jupita Jupiter	71 492 km	1.3 g/cm^3		2.540	23.12 m/s^2	2.36
Zohali Saturn	60 268 km	0.7 g/cm^3		1.070	8.96 m/s^2	0.91
Uranus Uranus	25 559 km	1.2 g/cm^3		0.800	8.69 m/s^2	0.88
Neptun Neptune	25 269 km	1.7 g/cm^3		1.200	11.00 m/s^2	1.12
Mwezi Moon					1.62 m/s^2	0.16

Shughuli ya 11: Mfano wa "volta za athari"

Activity 11: Model of "impact craters"

- Funika sakafu na magazeti ili kuzuia fujo
- Katika kisanduku kisicho na kina, weka safu ya sm 1 au 2 ya unga na kichujio ili kufanya uso kuwa laini sana.
- Nyunyiza safu ya milimita chache ya poda ya kakao juu ya unga na kichujio
- Kutoka kwa takriban m 2 kwenda juu, dondosha kijiko cha chakula cha poda ya kakao ili kuunda alama kama vile mashimo ya athari
- Unga uliotumika unaweza kutumika tena kwa jaribio jipya

- Cover the floor with newspapers to prevent a mess
- In a shallow box, set a layer of 1 or 2 cm of flour with a strainer to make the surface very smooth
- Sprinkle a layer of a few millimetres of cocoa powder over the flour with the strainer
- From about 2 m high, drop a tablespoon of cocoa powder to create marks like impact craters
- The used flour can be recycled for a new experiment

Shughuli 12: Kasi ya kutoroka

Activity 12: Escape velocity

- $E_{kin} = \frac{1}{2} mv^2$
- $E_{pot} = -GM_{planet}m/R_{planet}$
- $E_{mec} = E_{kin} + E_{pot} = 0$
- $g_{planet} = GM_{planet}/R^2_{planet}$

Then: $-GM_{planet}m/R_{Planet} + \frac{1}{2} mv^2 = 0$

$$\frac{1}{2} mv^2 = g_{planet}mR_{planet}$$

the scape velocity results:

$$v = (2gR)^{1/2}$$

Shughuli 12: Kasi ya kutoroka

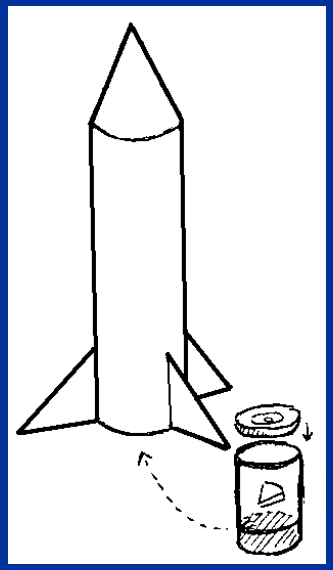
Activity 12: Escape velocity

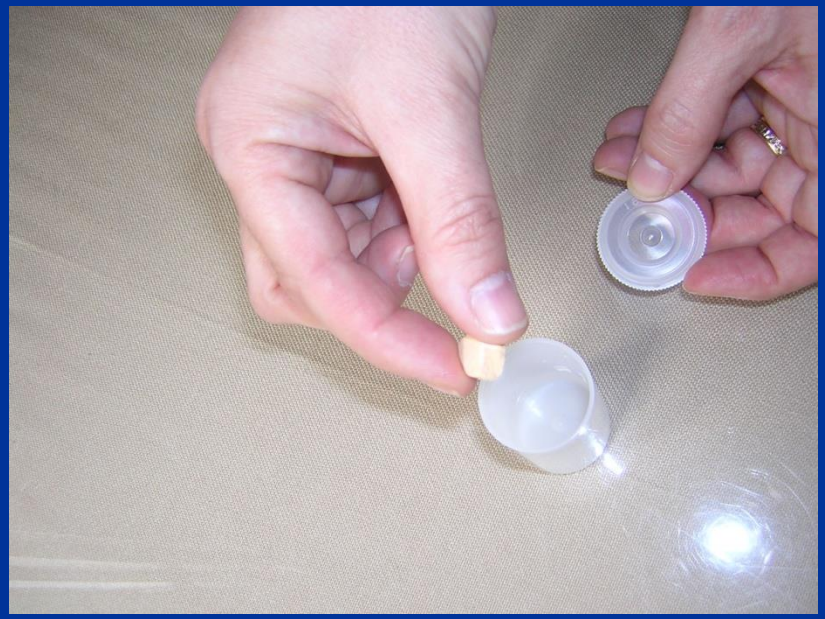
Sayari Planets	**Ikweta Radius** Equatorial Radius	g_{Planet}/g_{Earth}		**Kutoroka Kasi** Escape Velocity
Zebaki Mercury	2 439 km	0.378	⇒	4.3 km/s
Zuhura Venus	6 052 km	0.894	⇒	10.3 km/s
Dunia Earth	6 378 km	1.000	⇒	11.2 km/s
Mirihi Mars	3 397 km	0.379	⇒	5.0 km/s
Jupita Jupiter	71 492 km	2.540	⇒	59.5 km/s
Zohali Saturn	60 268 km	1.070	⇒	35.6 km/s
Uranus Uranus	25 559 km	0.800	⇒	21.2 km/s
Neptun Neptune	25 269 km	1.200	⇒	23.6 km/s

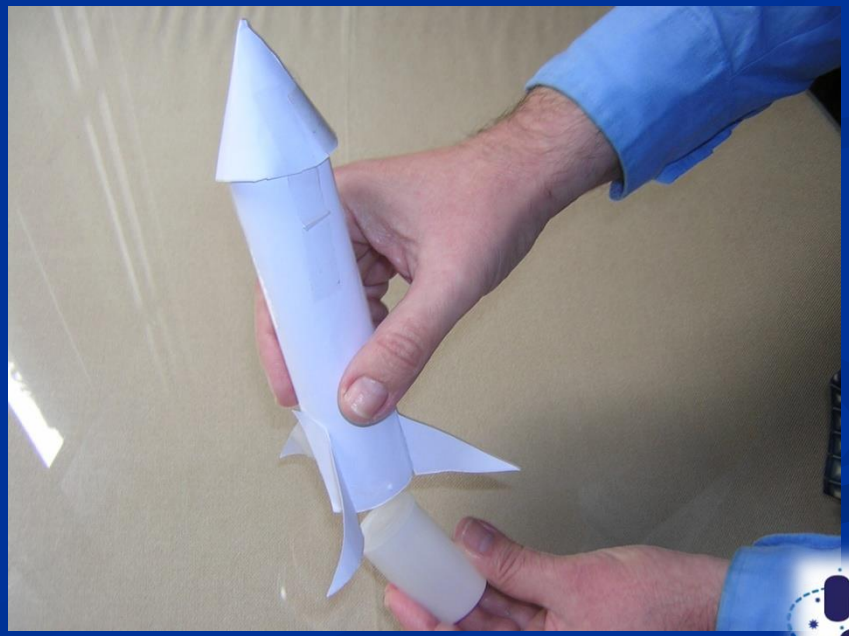
Shughuli 12: Urushaji wa roketi

Activity 12: Rocket launch

- Kadibodi
- Chombo cha filamu
- ¼ Vidonge vyenye ufanisi
  - Cardboard
  - Film container
  - ¼ Effervescent tablets







Mifumo ya sayari ya ziada ya jua

Extrasolar planetary systems

Mnamo 1995 Michael Meya na Didier Queloz walitangaza kugunduliwa kwa sayari ya nje inayozunguka 51 Pegasi.

In 1995 Michael Mayor and Didier Queloz announced the detection of an exoplanet orbiting 51 Pegasi

2M1207b directly imaged (ESO)

Picha ya kwanza ya exoplanet

Tarehe 16 Machi 2003

The first image of an exoplanet

2003 March 16th

Tunategemea teknolojia

We depend on the technology

Galilei alitazama Zohali na darubini yake mnamo 1610 kwa mara ya kwanza. Hakuona pete nzuri bali aliitafsiri kama nyota yenye miili mitatu.

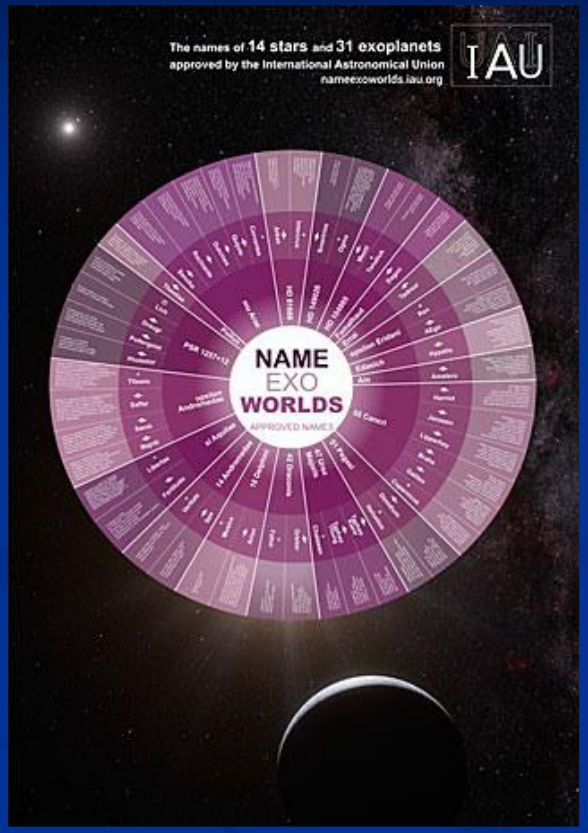
Ilibidi umngojee Huygens (1659) na darubini bora kutatua pete. Kwa sababu hii uchoraji wa Rubens (1636-1638) unaashiria Zohali na vitu vitatu kulingana na ugunduzi wa Galilei.

Galilei observed Saturn with his telescope in 1610 for the first time. He did not see a fine ring but interpreted it as a star with three bodies.

You had to wait for Huygens (1659) with a better telescope to solve the ring. For this reason the painting of Rubens (1636-1638) symbolizes Saturn with three objects according to the discovery of Galilei.

Majina ya exoplanets

Names for exoplanets



Barua huwekwa baada ya jina la nyota ya kati inayoanza na "b" kwa sayari ya kwanza inayopatikana kwenye mfumo (51 Pegasi b).

A letter is placed after the name of the central star starting with "b" for the first planet found in the system *(e.g. 51 Pegasi b)*.

Sayari inayofuata inaitwa kwa herufi inayofuata ya alfabeti c, d, e, f, nk.

The next planet is named with the next letter of the alphabet c, d, e, f, etc.

(51 Pegasi c, 51 Pegasi d, 51 Pegasi e or 51 Pegasi f).

Njia za kugundua exoplanet

Exoplanet detection methods

Mbinu nyingi hutumiwa:

- **Kasi ya Radi na Athari ya Doppler**
- **Njia ya Usafiri**
- **Microlensing**
- **Wengine**

Many methods are used:

- **Radial Velocity and Doppler Effect**
- **Transit Method**
- **Microlensing**
- **Others**

Njia ya Kugundua: Kasi ya Radi

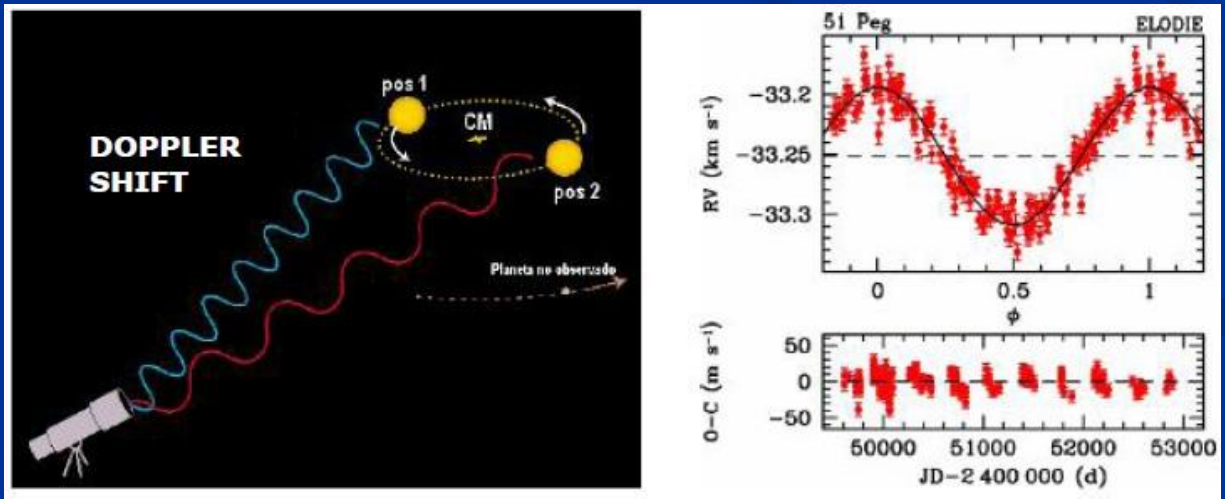
Detection Method: Radial Velocity

Tofauti ya kasi ya radial ya nyota wakati wa kuzunguka barycenter ya sayari na mfumo wa nyota hupimwa kwa kutumia Athari ya Doppler.

Ilikuwa kwa njia hii kwamba exoplanet ya kwanza 51 Pegasus b iligunduliwa.

The variation of the radial velocity of the star when orbiting the barycenter of the planet and star system is measured using the Doppler Effect.

It was with this method that the first exoplanet 51 Pegasus b was detected.



Zoezi 13: Athari ya Doppler

Activity 13: Doppler Effect

Athari ya Doppler ina badilisha masafa ya mwanga wakati chanzo cha mwanga kinatembea.

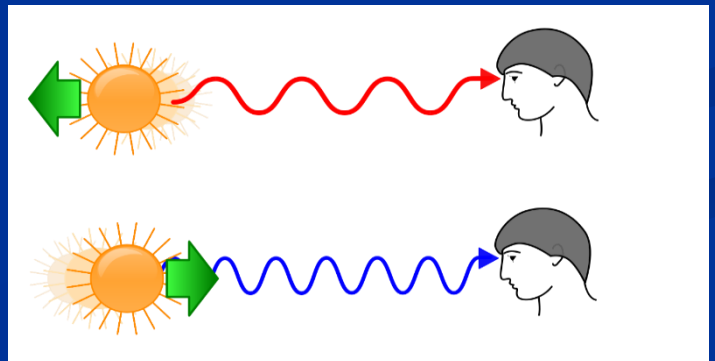
The Doppler effect is the change of the wavelength of the light when the source is in motion.

Chazo kinapokujia masafa hupungua na mwanga unahamia upande wa bluu wa mwanga onekani

When the source approaches wavelength is shortened **and the observed light shifting to the blue part of the visible spectrum.**

Kinapotoroka masafa huongezeka na mwanga unasogea upande wa wekundu wa mwanga onekani

When it moves away, the wavelength lengthens and the observed light shifting to the red part of the visible spectrum.

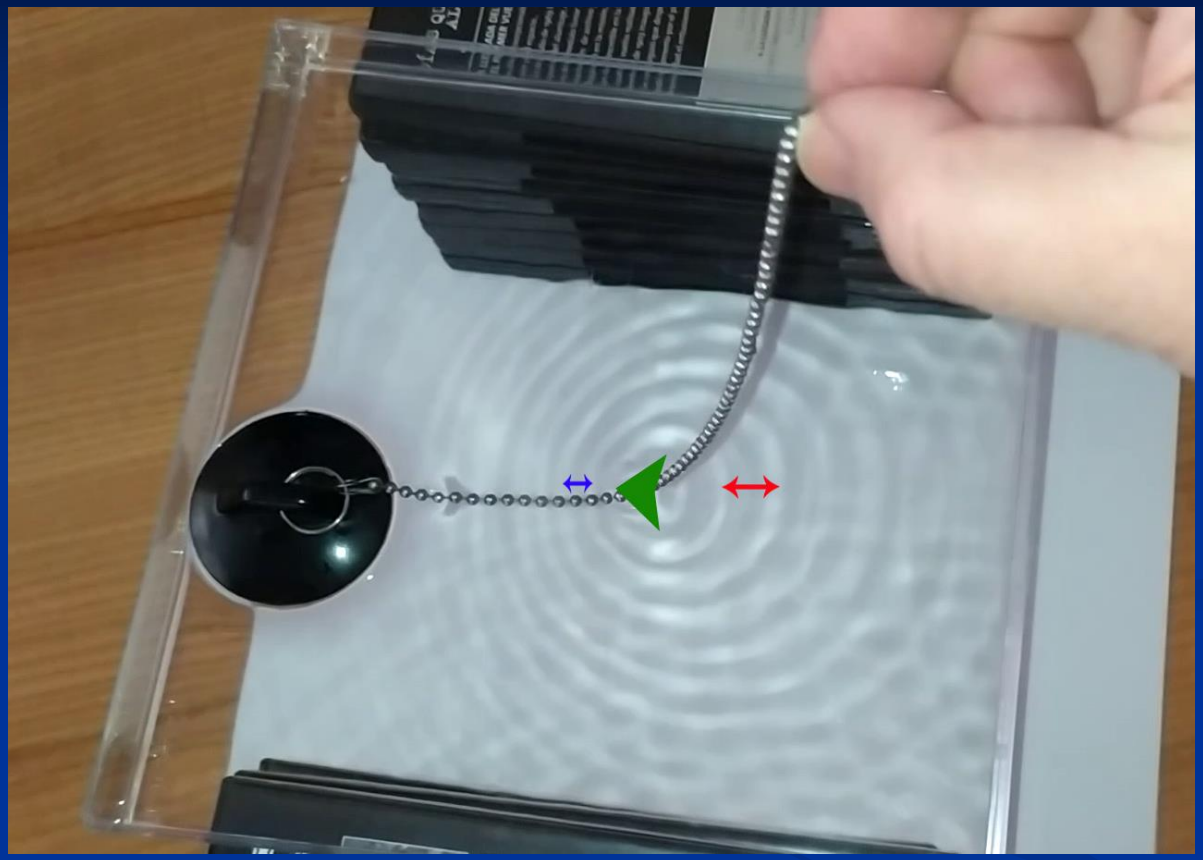


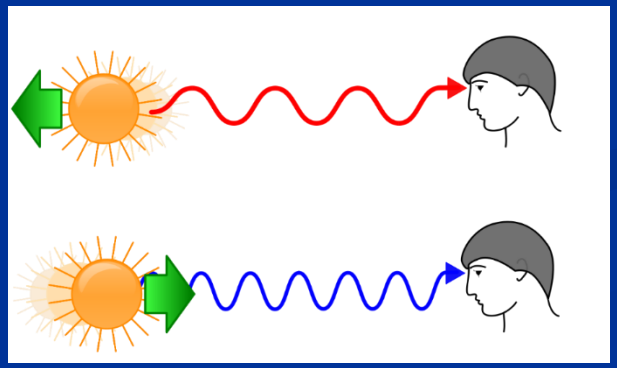
Zoezi 13: Athari ya Doppler

Activity 13: Doppler Effect

Hii imetokana na ndoo ya maji, mfuniko na cheni, na tochi ya mkononi

This has been reproduced with a bucket of water, a cap with chain and the mobile flash.





Njia ya Utambuzi: Mpito

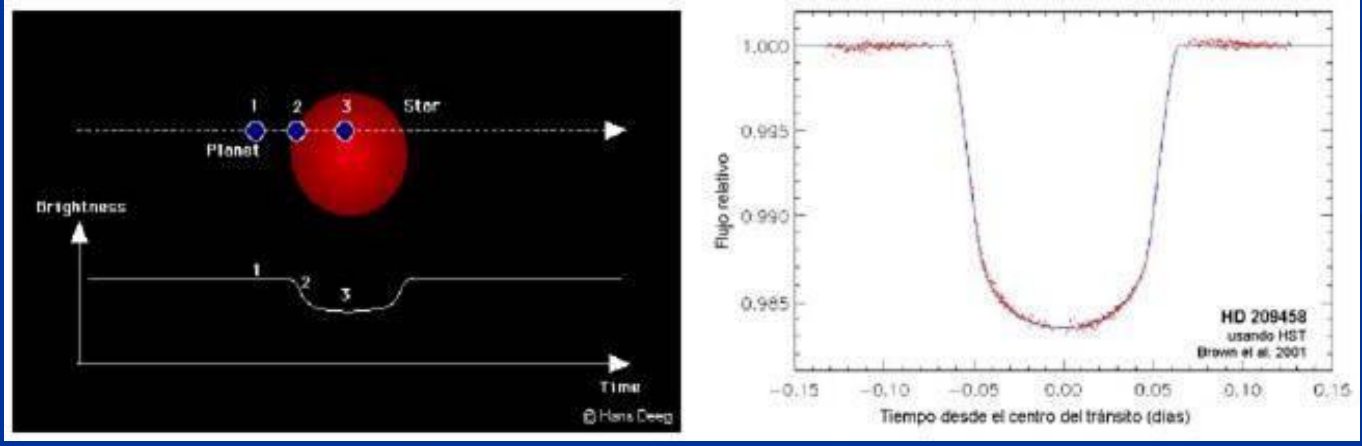
Detection Method: Transits

Wakati wa mpito wa sayari-nje, kiasi cha nuru ya mwanga unapungua kidogo.

During the transit of an exoplanet, the brightness of the star undergoes a small decrease.

Kwa nytoa na ukubwa wa Jua na sayari-nje za ukubwa wa Mshtarii, pungukio wa nuru ni kiasi asilimia 1%, na kwa sayari-nje saizi ya Dunia punguo ni asilimia 0.003%.

For solar-type stars and Jupiter-sized planets, the brightness decrease is approximately 1%, in the case of Earth-sized planets the decrease is around 0.03%.



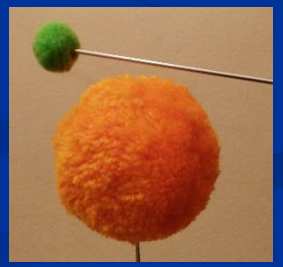
Zoezi 14: Mfananisho wa Mpito

Activity 14: Transit simulation

Kwa kutumia mipira miwili, moja kubwa na moja ndogo, za kufananisha nyota kubwa na sayari-nje yake ndogo inayoizunguka nyota hiyo

Using two balls: one large for the star and one small for the exoplanet orbiting the star.

Observer in the plane of the orbit



Observer out of the plane of orbit

Zoezi 14: Mfananisho wa Mpito

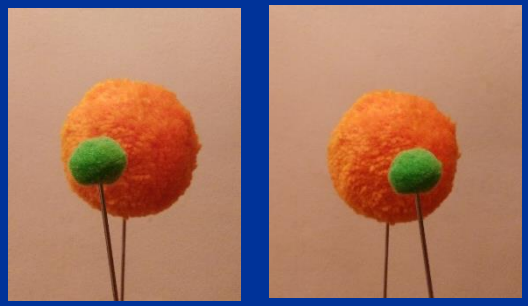
Activity 14: Transit simulation

Mtazamaji akiweka macho kwenye bapa ya obiti na akiangalia kutoka hapo, utaona sayari-nje ikipita mbele ya nyota na mwanga utapungua.

With the observer in the same plane of the orbit and observing from that place, you will see the exoplanet passing in front of the star and the brightness of the star decreasing.

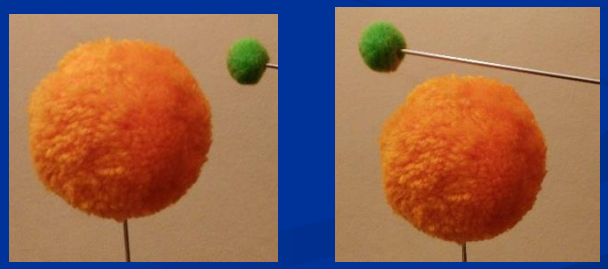
Lakini mtazamaji asipokuwa katika bapa ya obiti, hakutakuwa na tofauti ya katika mwanga.

But if the observer is not in the same plane of orbit, no change in the brightness curve will be observed.



Mtazamaji katika bapa ya obiti

Observer in the plane of the orbit



Mtazamaji nje ya bapa ya obiti

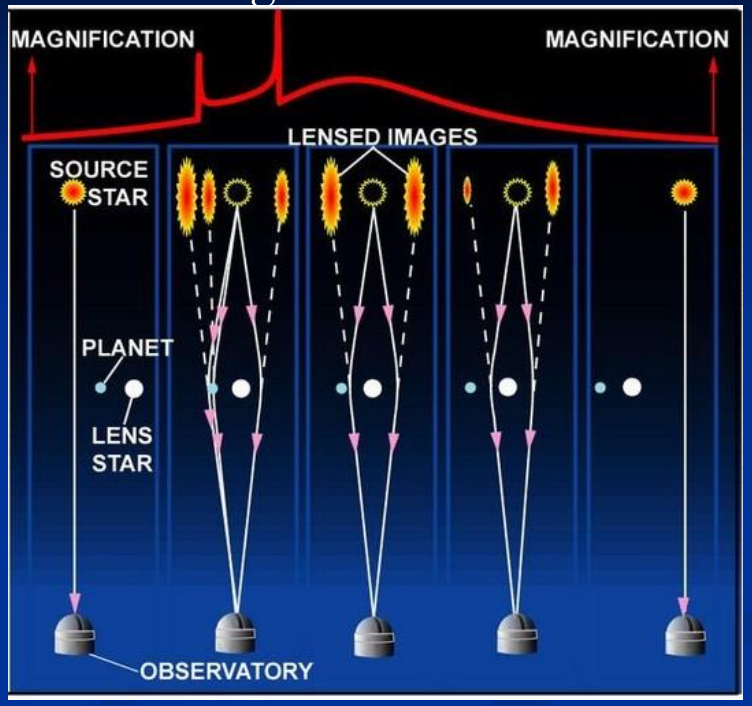
Observer out of the plane of orbit

Njia ya Utambuzi: Lenzi Mfinyo

Detection Method: Micro Lensing

Kunakuwa na upanuzi au upoto unaoashiria uwepo kwa nyota na sayari-nje yake, kwa vile zinakuwa mstari mnyoofu na gimba linalopinda mwanga kwa gravity yake kali.

There is an enlargement or distortion that highlights the star-exoplanet system, due to the alignment of the system with a star or object that makes the gravitational lens.

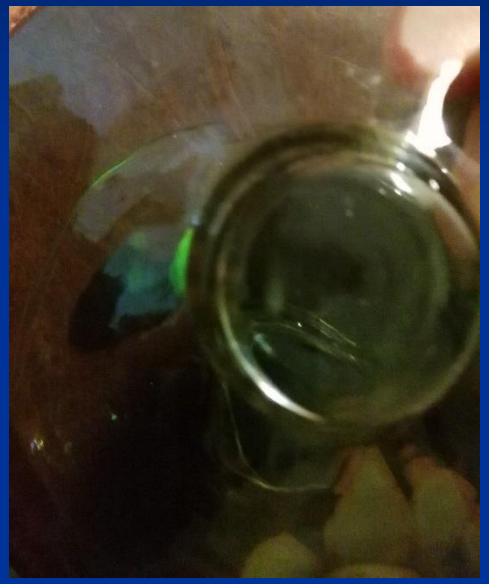


Lazima kuwe na unyoofu wa kuona kati ya magimba haya matatu (Dunia, gimba la gravity kubwa, na nyota na sayari-nje yake.

There must be complete visual alignment between the three bodies (earth, object-lens and star-exoplanet).

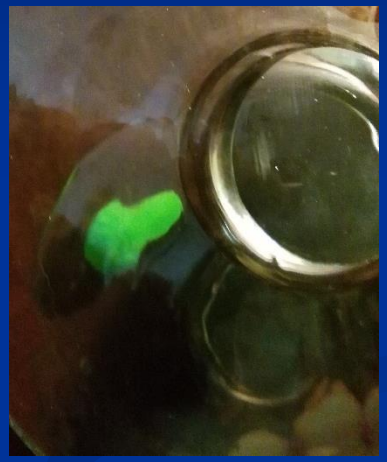
Zoezi 15: Mfananisho wa lenzi finyu

Activity 15: Simulation of microlenses



Kwa kutumia mguu wa glasi moja tu ya waini

With only one wine glass foot, nothing is seen.



Kwa miguu miwili ya glasi 2 za waini

With a pair of wine glass feet

Tunapitisha moja juu ya nyingine na pointi moja inatokeza na hata pointi mbili

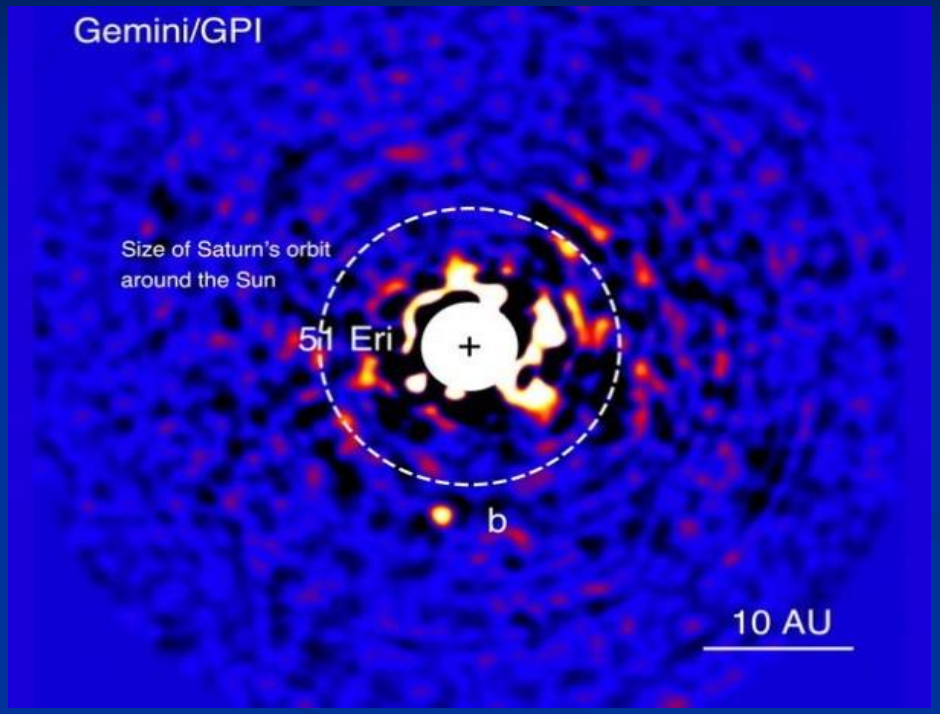
Then we pass one over the other and a point emerges and then even two.

Njia ya Utambuzi: Moja kwa moja

Detection Method: Direct

Taswira ya nyota inaangaliwa kuona sayari-nje zinazoizunguka

The image of the star is studied to determine the exoplanets around it.

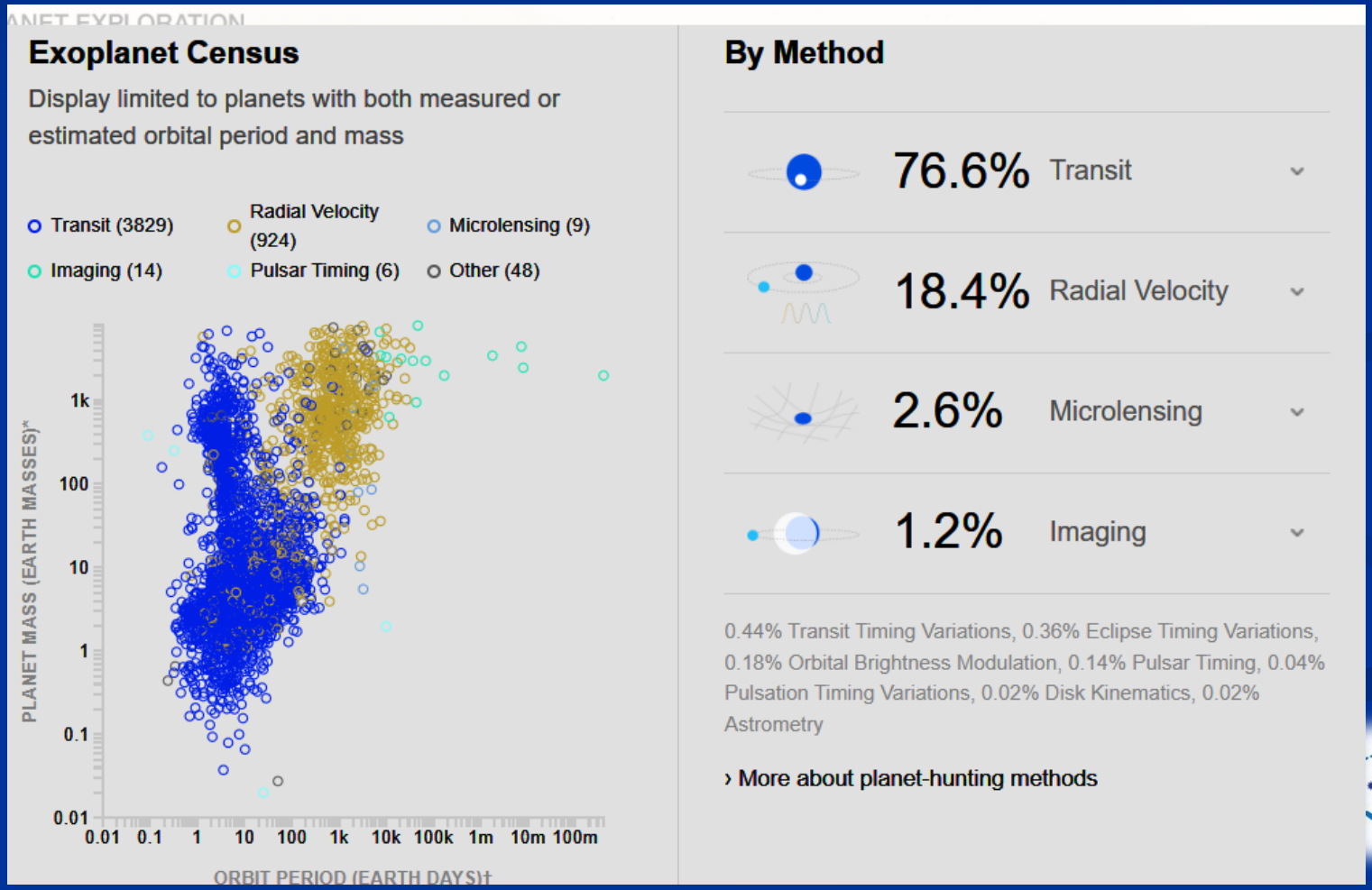


Kutokana na kiasi kikubwa cha mwanga unaotolewa na nyota, si rahisi kutumia njia hii

Due to the amount of light emitted by the star, it is not easy to carry out.

Sayari-nje 5,000 zilizotambulika kwa kutumia njia tofauti

5,000 known exoplanets according to the different detection methods



Mifano ya mifumo ya sayari-nje

Models of exoplanet systems

Kuna zaidi ya sayari-nje 5000 zilizothibitishwa na maelefu mengine zinachunguzwa.

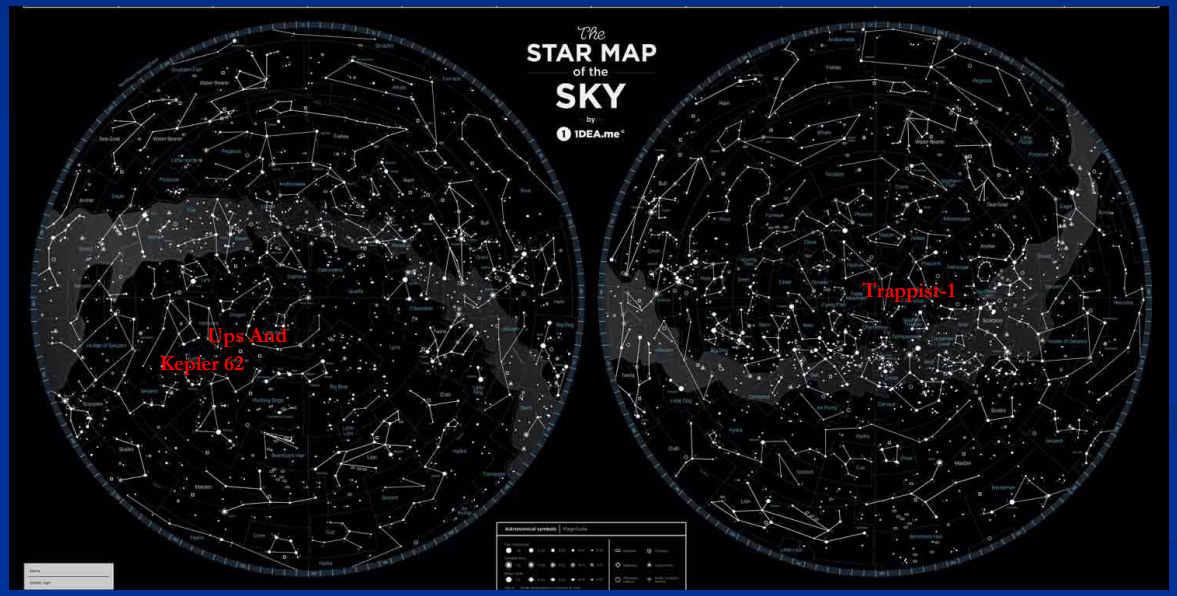
There are more than 5000 exoplanet systems confirmed and several thousand candidate exoplanets

Jet Propulsion Laboratory (NASA; http://planetquest.jpl.nasa.gov/)

Masi za sayari-nje zinlinganishwa na masi ya Mstarii (Jupiter) (1.9×10^{27} kg) au na masi ya Dunia (5.97×10^{24} kg). The masses are compared with Jupiter (1.9×10^{27} kg) or the Earth (5.97×10^{24} kg).

Zoezi la 16: Mifano mizani ya mifumo ya sayari-nje

Activity 16: Scale models of exoplanetary systems



Umbali AU 1 = mita 1

Distance 1 AU = 1 m

Kipenyo km 10,000 = cm 0.5

Diameter 10000 km = 0.5 cm

Zoezi la 17: Jenga Mfumo wa Jua:

Activity 16: Build Solar System:

Mfumo wa Jua Solar System	**Umbali AU** Distance AU	**Kina km** Diameter Km	**Umbali wa Mfano** Model Distance	**Kipenyo cha Mfano** Model Diameter
Utarid Mercury	**0.39**	**4879**	**40 cm**	**0.2 cm**
Zuhura Venus	**0.72**	**12104**	**70 cm**	**0.6 cm**
Dunia Earth	**1**	**12756**	**1m**	**0.6 cm**
Mirihi Mars	**1.52**	**6794**	**1.5 m**	**0.3 cm**

Nyota mama ni Jua G2V, Kipenyo cha Jua katika mfano ni cm 35

Host Star Sun G2V, Diameter of the Sun in the model is 35 cm

Umbali AU 1 = mita 1 (Distance 1 AU = 1 m)
Kipenyo km 10,000 = cm 0.5 (Diameter 10,000 km = 0.5 cm)

Zoezi la 17: Jenga Mfumo wa Jua:

Activity 16: Build Solar System:

Mfumo wa Jua Solar System	**Umbali AU** Distance AU	**Kina km** Diameter Km	**Umbali wa Mfano** Model Distance	**Kipenyo cha Mfano** Model Diameter
Mstarii Jupiter	**5.2**	**142984**	**5 m**	**7 cm**
Zohali Saturn	**9.55**	**120536**	**10 m**	**6 cm**
Uranus	**19.22**	**51118**	**19 m**	**2.5 cm**
Neptuni	**30.11**	**49528**	**30 m**	**2.5 cm**

Nyota mama ni Jua G2V, Kipenyo chaJua katika mfano ni cm 35

Host Star Sun G2V, Diameter of the Sun in the model is 35 cm

Umbali AU 1 = mita 1 (Distance 1 AU = 1 m)
Kipenyo km 10,000 = cm 0.5 (Diameter 10,000 km = 0.5 cm)

Zoezi la 16: Jenga mfumo wa kwanza wa sayari-nje

Activity 16: Build 1st exoplanetary system:

Mfumo wa Upsilon Andromedae **Titawin**	**Mwaka wa kugunduli wa** Discovery year	**Umbali** Distance **AU**	**Kipenyo** Diameter **km**	**Umbali wa Mfano** Model Distance	**Kipenyo cha Mfano** Model Diameter
Ups And b/Saffar	1996	**0.059**	**108 000**	**6 cm**	**5.5 cm**
Ups And c/Samh	1999	**0.830**	**200 000**	**83 cm**	**10 cm**
Ups And d/Majriti	1999	**2.510**	**188 000**	**2.5 m**	**9 cm**
Ups And e/Titawin e	2010	**5.240**	**140 000**	**5.2 m**	**7 cm**

Nyota mama "Ups Andromedae F8V" ipo ly 44

Host Star Ups Andromedae F8V is at 44 l.y.

Na Kipenyo mara 1.28 cha Jua na ya mfano ni cm 45

And 1.28 Diameter of the Sun in the model is 45 cm

Umbali AU 1 = mita 1 (Distance 1 AU = 1 m)
Kipenyo km 10,000 = cm 0.5 (Diameter 10,000 km = 0.5 cm)

Zoezi la 16: Jenga sayari za kiArdhi

Activity 16: Build "terrestrial" planets

Gliese 581	**Mwaka wa kugunduli wa** Discovery year	**Umbali** Distance **AU**	**Kipenyo** Diameter **km**	**Umbali wa Mfano** Model Distance	**Kipenyo cha Mfano** Model Diameter
Gl.581 e	2009	**0.030**	**15 200**	**3 cm**	**0.8 cm**
Gl.581 b	2005	**0.041**	**32 000**	**4 cm**	**1.6 cm**
Gl.581 c	2007	**0.073**	**22 000**	**7 cm**	**1.1 cm**

Nyota mama Gliese 581 M2,5V ni ly 20.5 katika kundinyota Mizani

Host star Gliese 581 M2,5V is 20,5 l.y. in Libra,

Kipenyo 0.29 ya Jua katika mfano ni cm 10

Diameter 0.29 of the Sun in the model is 10 cm

Umbali AU 1 = mita 1 (Distance 1 AU = 1 m)

Kipenyo km 10,000 = cm 0.5 (Diameter 10,000 km = 0.5 cm)

Zoezi la 16: Jenga sayari-nje za kiArdhi za kiuhai

Activity 16: Build "habitable terrestrial"planets

Kepler 62	**Mwaka wa kugundul iwa** Discovery year	**Umbali** Distance **AU**	**Kipenyo** Diameter **km**	**Umbali wa Mfano** Model Distance	**Kipenyo cha Mfano** Model Diameter
Kepler-62 b	2013	**0.056**	**33 600**	**5.6 cm**	**1.7 cm**
Kepler-62 c	2013	**0.093**	**13 600**	**9 cm**	**0.7 cm**
Kepler-62 d	2013	**0.120**	**48 000**	**12 cm**	**2.4 cm**
Kepler-62 e	2013	**0.427**	**40 000**	**43 cm**	**2 cm**
Kepler-62 f	2013	**0.718**	**36 000**	**72 cm**	**1.8 cm**

Nyota mama Kepler 62 K2Vni ly 1200 katika kundinyota ya Shaliaki

Host star Kepler 62 K2V is at 1200 l.y. in Lyr,.

Kipenyo ni 0.64 ya Jua na katika mfano ni cm 22

Diameter 0.64 of the Sun in the model is 22 cm

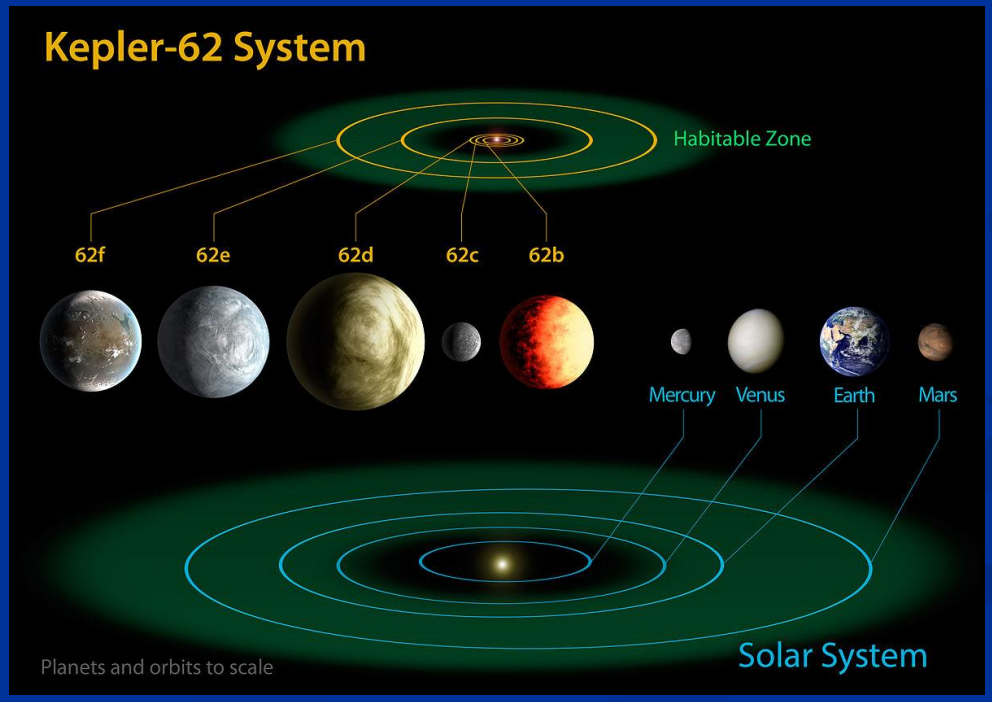
Umbali AU 1 = mita 1 (Distance 1 AU = 1 m)
Kipenyo km 10,000 = cm 0.5 (Diameter 10,000 km = 0.5 cm)

Uwezekano wa viumbe hai katika sayari-nje

Possible habitability of exoplanets

Katika eneo la kuweza kuwa na viumbe venyeuhai katika Kepler-62 sayari-nje mbili zinaweza kuwa na maji miminika kwenye sura zao.

In the habitable zone of Kepler-62: the two exoplanets could have liquid water on their surfaces.

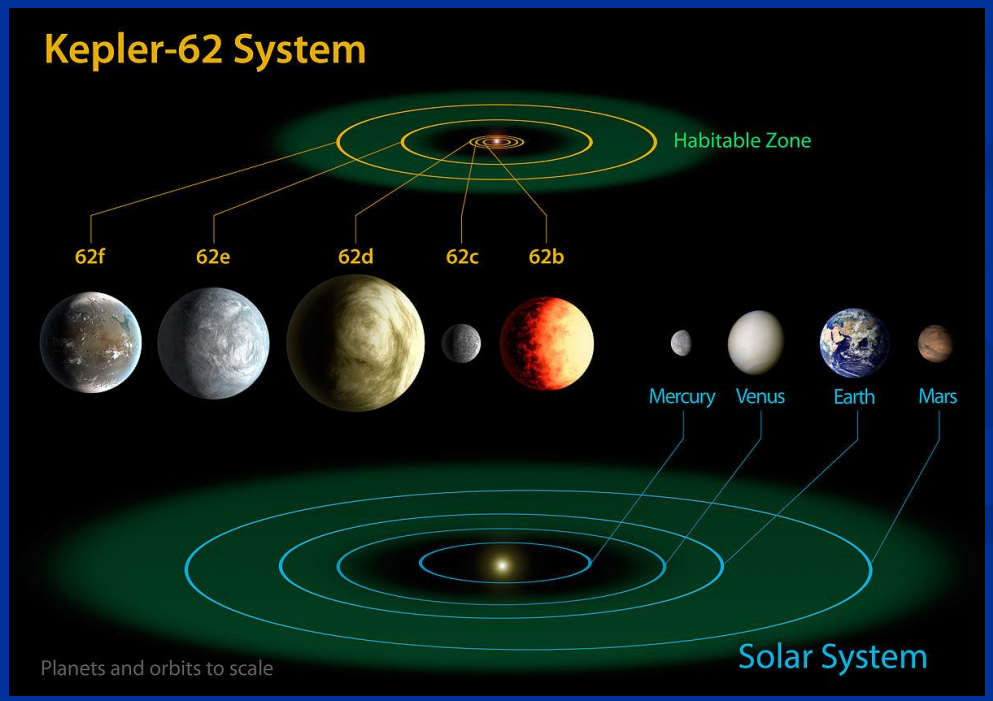


Uwezekano wa viumbe hai katika sayari-nje

Possible habitability of exoplanets

Katika sayari-nje 62c, ambayo iko eneo la ndani la kuweza kuwa na viumbe hai. Sayari-nje hiyo inaweza kuhitaji kufunikwa kwa mawingu ya kuakisi mwanga ili kupunguza mwanga wa utakaosababisha sura kupata joto.

- For Kepler-62e, which is near the interior of the habitable zone, this would require coverage of reflective clouds that reduces the radiation that heats the surface.

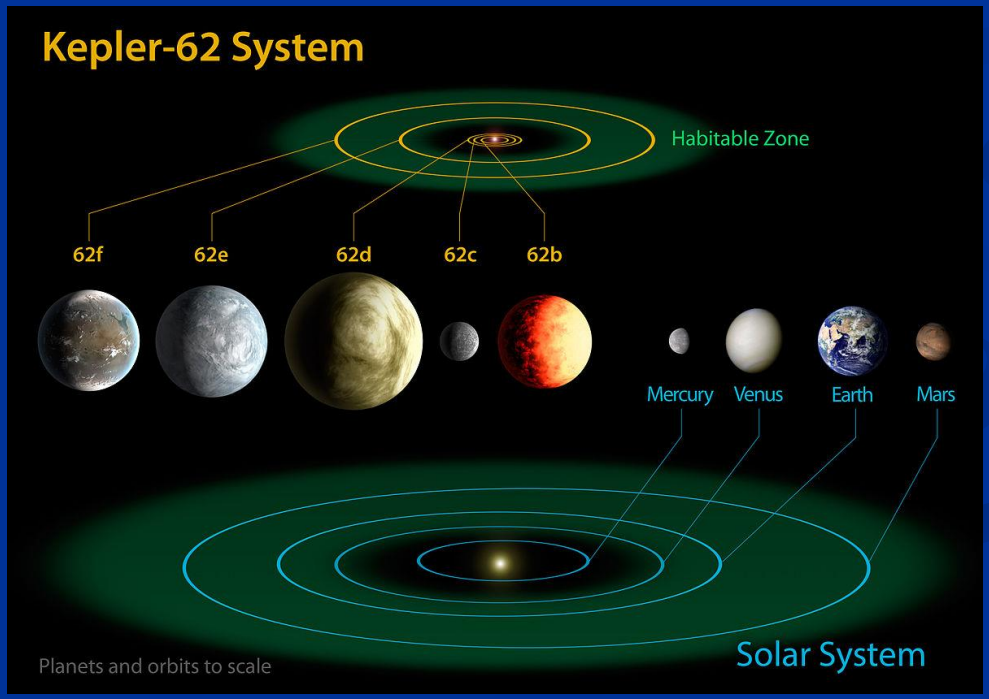


Uwezekano wa viumbe hai katika sayari-nje

Possible habitability of exoplanets

Kepler 62f, iko upande wa pili wa eneo la kuweza kuwa na viumbe hai

Kepler-62f, on the other hand, is in the outer zone of the habitable zone



Zoezi la 16: Jenga sayari-nje zenye uhai

Activity 16: Build "habitable terrestrial"planets

Trappist-1	**Mwaka wa kugundul iwa** Discovery year	**Umbali** Distance **AU**	**Kipenyo** Diameter **km**	**Umbali wa Mfano** Model Distance	**Kipenyo cha Mfano** Model Diameter
Trappist-1 b	2016	**0.012**	**28 400**	**1.2 cm**	**1.4 cm**
Trappist-1 c	2016	**0.016**	**28 000**	**1.6 cm**	**1.4 cm**
Trappist-1 d	2016	**0.022**	**20 000**	**2.2 cm**	**1.0 cm**

Nyota mama Trappist 1 M8V ni ly 40 katika kundinyota la Ndoo

Host star Trappist 1 M8V is at 40 l.y. in Aquarius,

Kipenyo ni 0.1 ya Jua na ya mfano ni cm 3

Diameter 0.1 of the Sun in the model is 4 cm

Umbali AU 1 = mita 1 (Distance 1 AU = 1 m)
Kipenyo km 10,000 = cm 0.5 (Diameter 10,000 km = 0.5 cm)

Zoezi la 16: Jenga sayari-nje zenye uhai

Activity 16: Build "habitable terrestrial"planets

Trappist-1	Discovery year	Distance AU	Diameter km	Model Distance	Model Diameter
Trappist-1 e	2017	0.030	23 200	3.0 cm	1.2 cm
Trappist-1 f	2017	0.039	26 800	3.9 cm	1.3 cm
Trappist-1 g	2017	0.047	29 200	4.7 cm	1.5 cm
Trappist-1 h	2017	0.062	19 600	6.2 cm	1.0 cm

Nyota mama Trappist 1 M8V ni ly 40 katika kundinyota la Ndoo

Host star Trappist 1 M8V is at 40 l.y. in Aquarius,

Kipenyo ni 0.1 ya Jua na ya mfano ni cm 3

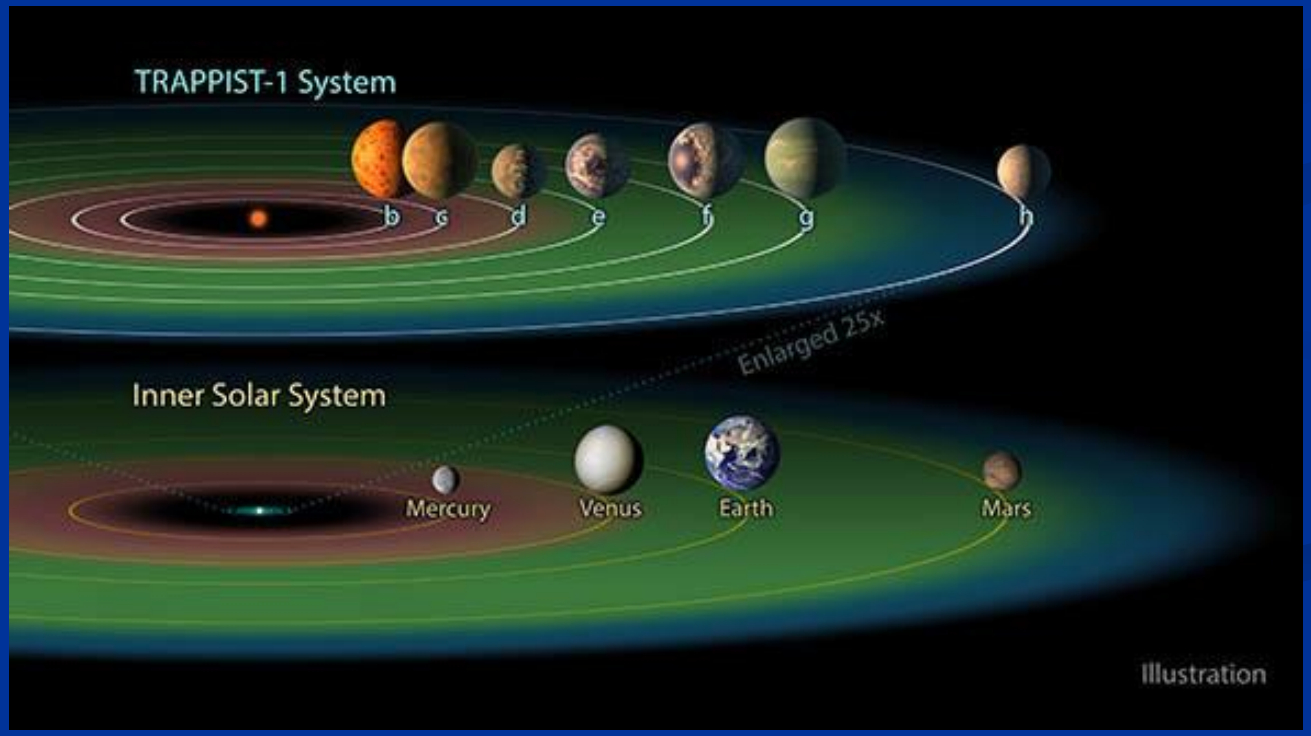
Diameter 0.1 of the Sun in the model is 4 cm

Umbali AU 1 = mita 1 (Distance 1 AU = 1 m)
Kipenyo km 10,000 = cm 0.5 (Diameter 10,000 km = 0.5 cm)

Uwezekano wa kuweza kuwa na viumbe hai katika sayari-nje

Possible habitability of exoplanets

- Mfumo wa Trappist-1, ni wa kimawe na unaweza kuwa na kiasi kikubwa cha maji katika sura zake, aidha kimiminika au mvuke, au gamba la barafu.
- In the Trappist-1 system are rocky and could have large amounts of water on their surface, either liquid, in the form of steam, or as an ice crust..

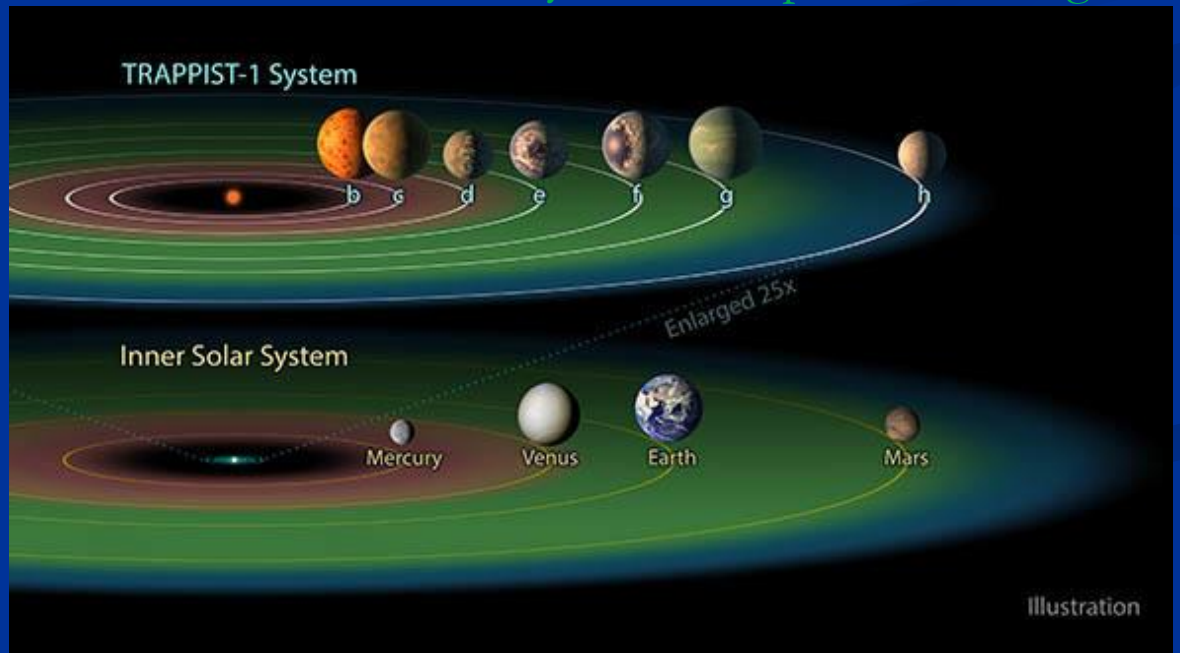


Uwezekano wa kuweza kuwa na viumbe hai katika sayari-nje

Possible habitability of exoplanets

Ndani ya eneo la kuweza kuwa na uhai la Trappist-1, kuna Trappist 1e ambayo inaelekea kuwa na kitovu kigumu sana sawa na katika Dunia ambayo inaashiria kwamba kati ya sayari-nje zote katika mfumo huu, hii ndiyo inakaribia zaidi Dunia na inawezekana sana kuwa na wavusumaku wa kulinda.

In the habitable zone of Trappist 1 is Trappist-1e which appears to have a dense nucleus, comparable to Earth which seems to indicate that of all the planets in this system, this is the most Earth-like and is likely to have a protective magnetosphere.



Hitimisho

Conclusions

- **Elimu ya sayari inafahamika zaidi sasa**
  - Knowledge is more "concrete" of planets
- **Mahusiano yanathibitisha “vipimo” vinavyofanikisha uelewa zaidi wa ukubwa**
  - Relationships establish "parameters" that allow a better understanding of dimensions
- **Mfumo wa Jua “ni tupu”**
  - The solar system "is empty"
- **Mwanzo wa sayari-nje. Kufahamu njia za kuzitafuta**
  - Introduction of exoplanets. Recognize the methods for detection.

Asanteni sana kwa usikivu!

Thank you for your attention!