

The search for Terra Nova

*Stellar music,
aliens,
alien Earths
and Canada's space telescope*



Jaymie Matthews

MOST Mission Scientist

*Associate Professor
Department of Physics & Astronomy
University of British Columbia*



Jaymie Matthews

Simpsonized
Scientist

Perspective is everything

sidewalk art

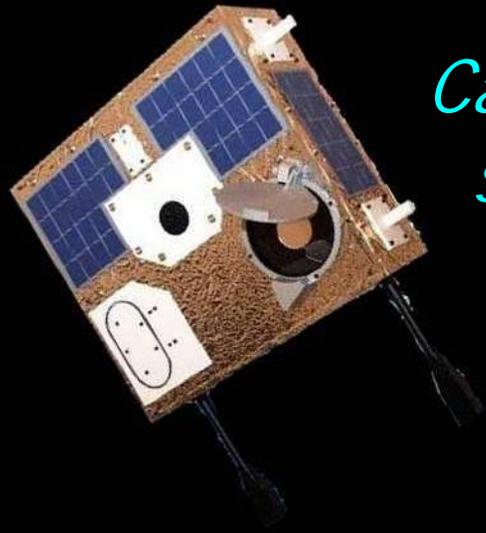
*seen from 180°
in the other direction*



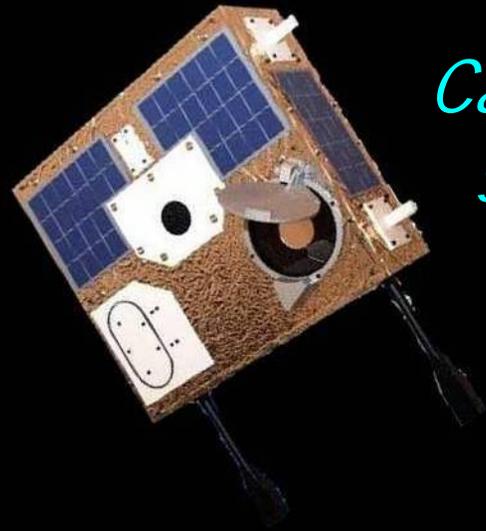
*seen from one
point of view*







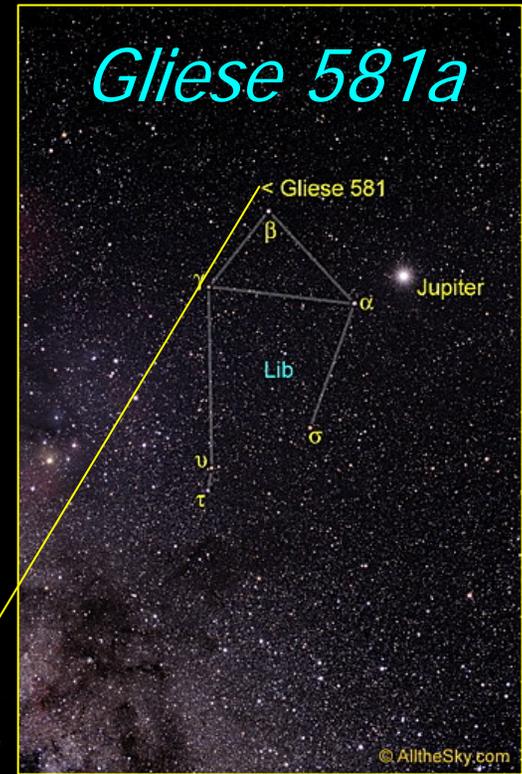
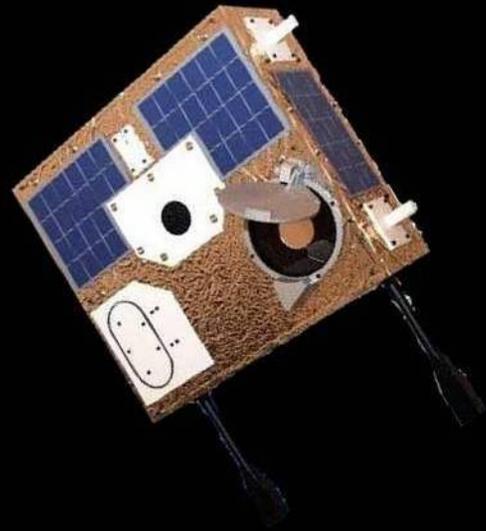
*Canada's
space
telescope*



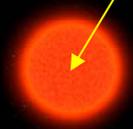
*Canada's
space
telescope*



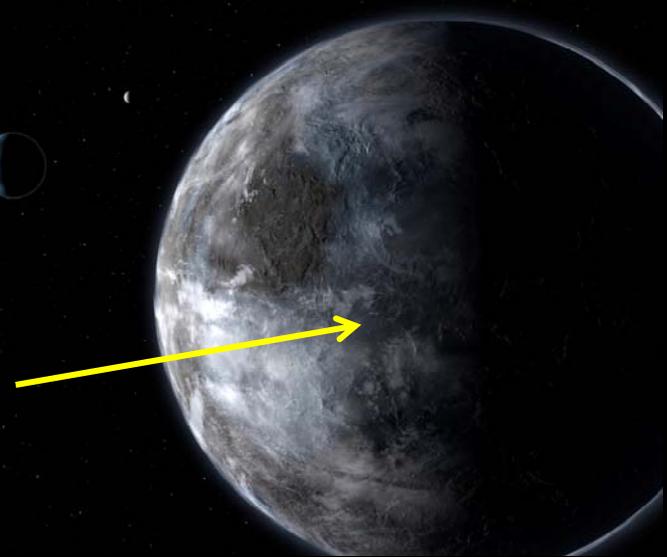
*Habitable
world*



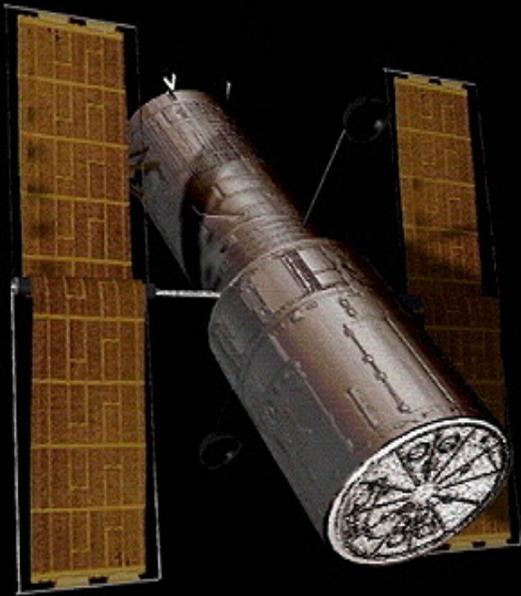
*red dwarf
star*



*Habitable
world?*



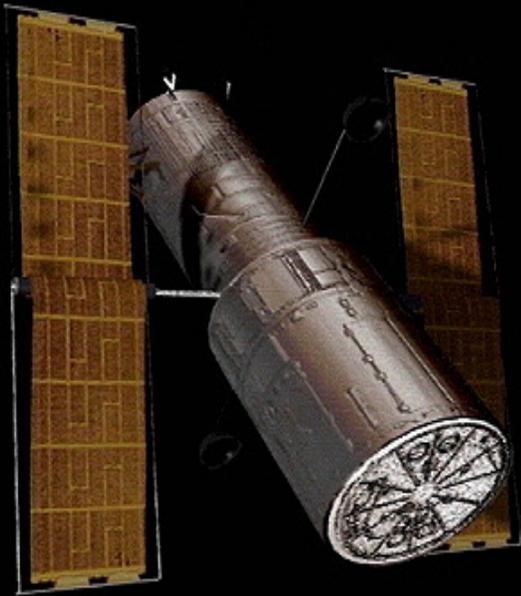
America's space telescope



Hubble Space Telescope

Canada's space telescope

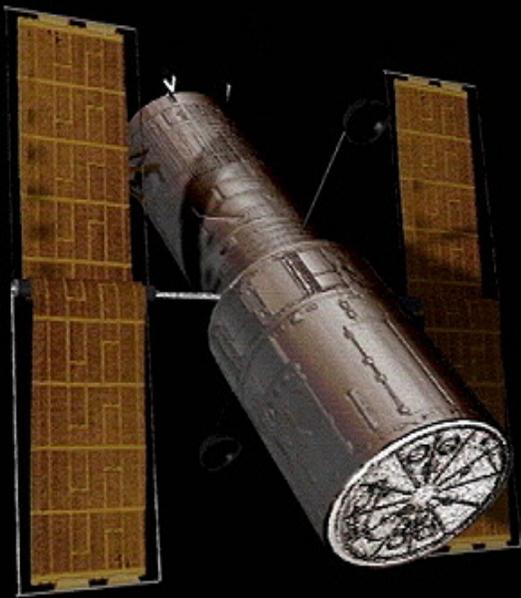
MOST



Hubble Space Telescope

Canada's space telescope
Microvariability & Oscillations of STars
Microvariabilité et Oscillations STellaire

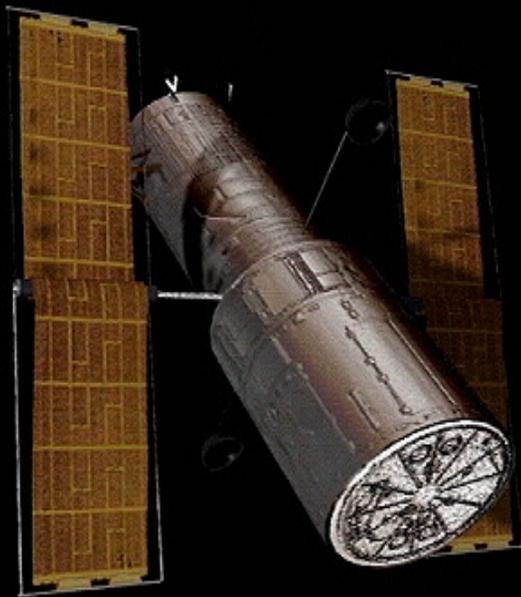
MOST



Hubble Space Telescope

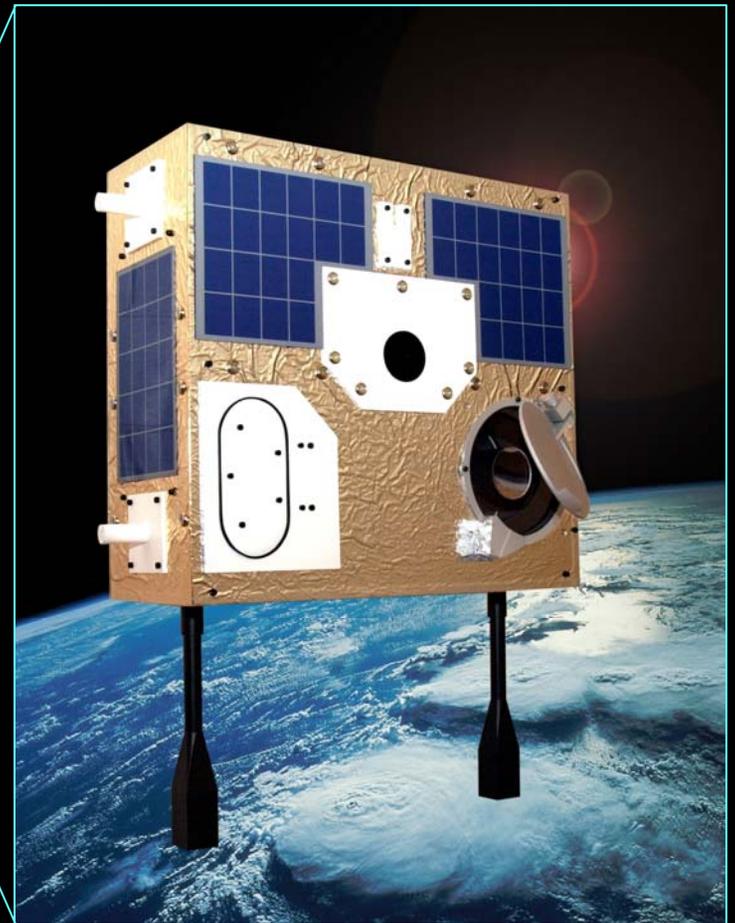
Canada's space telescope – MOST

The "Humble" Space Telescope

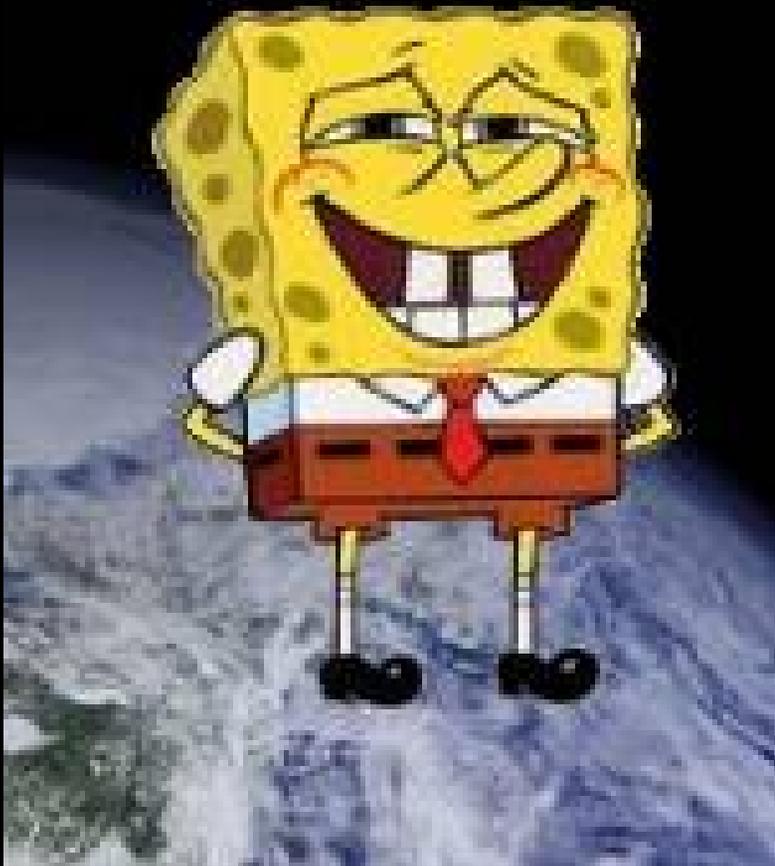


Hubble Space Telescope

MOST



Canada's space telescope – MOST
The "Hubble" Space Telescope Squarepants



Canada's space telescope – MOST

Continuing legacy of Alouette 1

First ...

- all-Canadian scientific satellite in over 30 years



Canadian Space Agency (CSA)



Canada's space telescope – MOST

Satellite

- ❑ 54 kg, 60×60×30 cm
- ❑ Power: solar panels
 - ❑ peak ~ 38 W
- ❑ Communication: radio
 - ❑ power of a cell phone
- ❑ Attitude Control System:
 - ❑ pioneering technology
 - ❑ pointing 4000× better
- ❑ Lifetime: 5 – 9 years +?

CONTRACTORS: *Dynacon Inc.*
U of T Institute for Aerospace Studies



Canada's space telescope – MOST

Mission Scientist

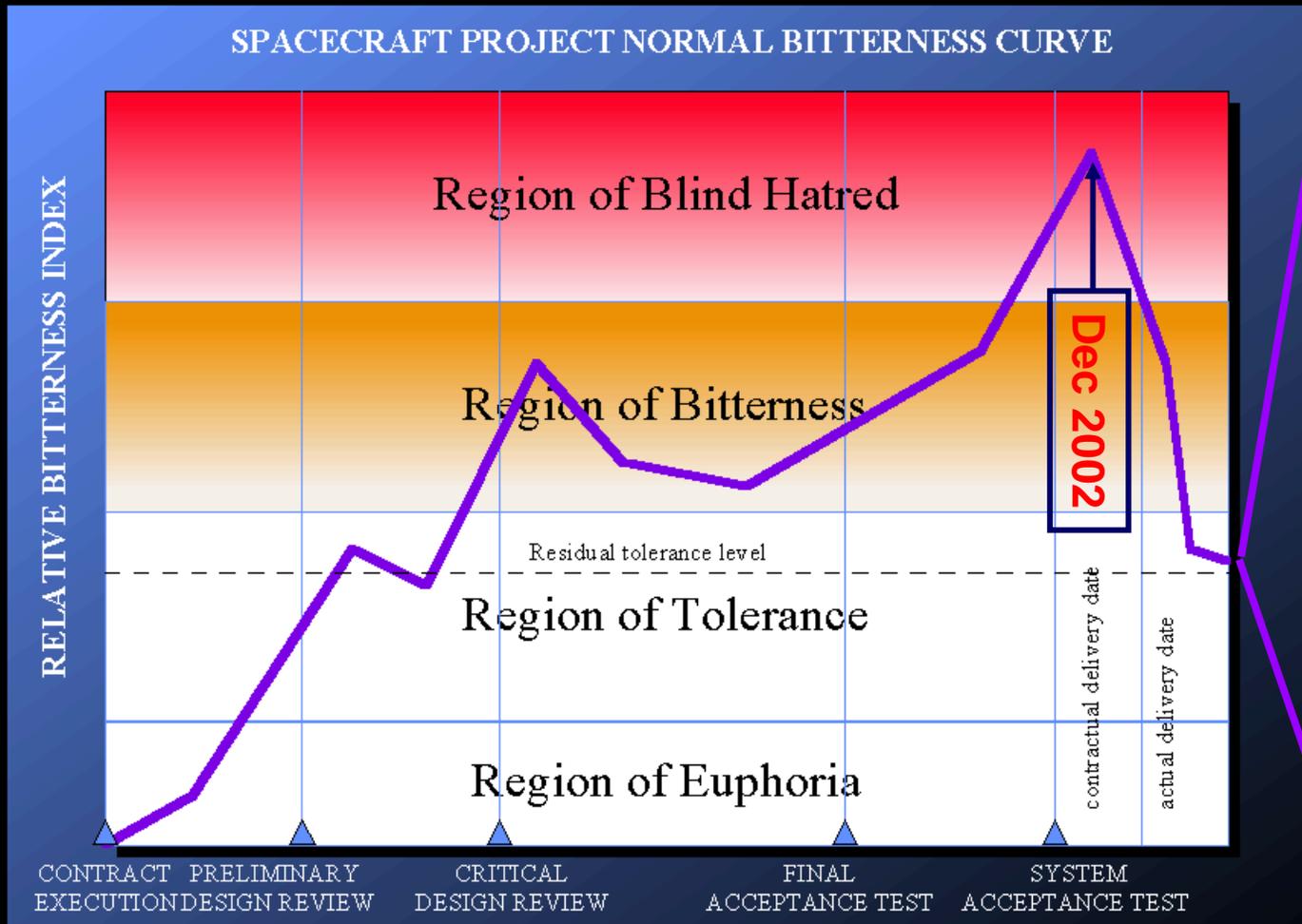
- ❑ > 54 kg, 182 cm tall
- ❑ Power: hydrocarbons
 - ❑ peak ~ 12 MW at clubs
- ❑ Communication: loud
 - ❑ no cell phone
- ❑ Attitude uncontrolled
 - ❑ pionerd technology
 - ❑ doesn't always have a point
- ❑ Lifetime: fun while it lasts

CONTRACTORS: *my parents*



MOST's (not so) long journey

proposed in 1997 → launched in 2003



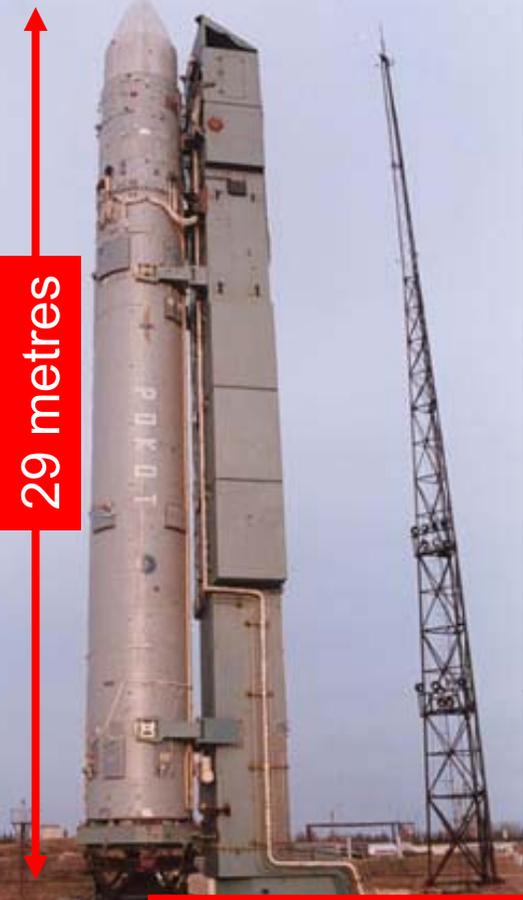


ROCKOT

3rd stage



3-stage former ICBM (SS-19) with low-orbit lift capacity ~1900 kg



29 metres

*Eurockot = Astrium +
Khrunichev Space Research Centre*

mass = 107 tonnes

Launch: 30 June 2003 - 16:15:00.323 UTC

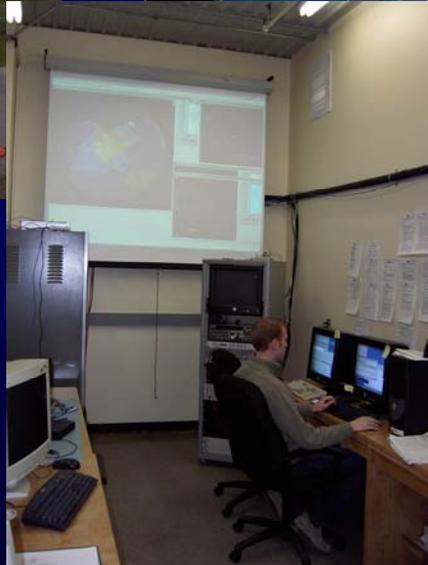


Plesetsk Cosmodrome



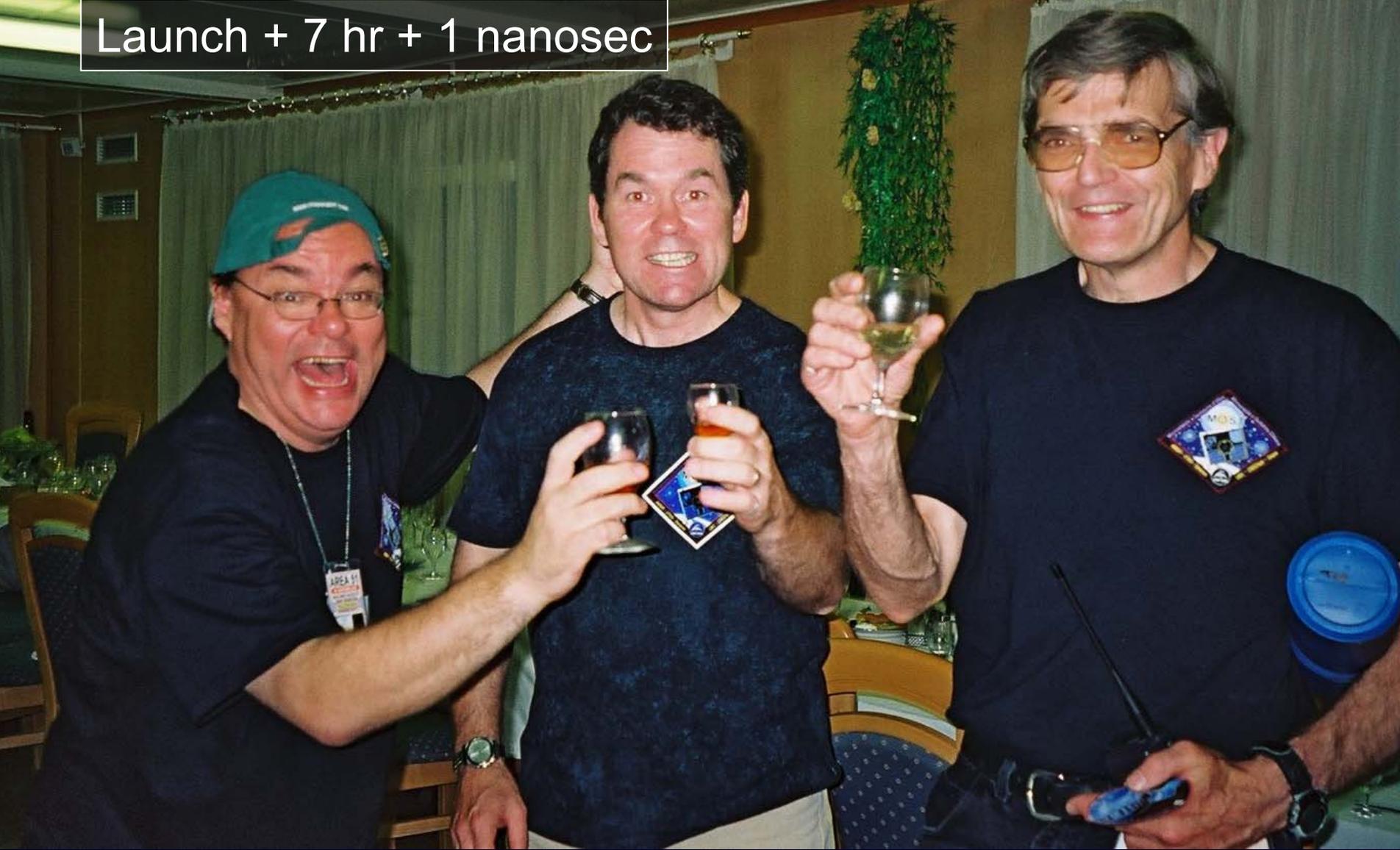
First contact: 30 June 2003 - 23:50:44.197 UTC

Launch + 7 hr



First contact: 30 June 2003 - 23:50:44.197 UTC

Launch + 7 hr + 1 nanosec



Mission Scientist reflects on success ...

Launch + 12 hr



MOST's unique vantage point

Orbit

MOST stares at stars for up to 2 months at a time without interruption.

- altitude $h = 820 \text{ km}$
- period $P = 101 \text{ min}$
- speed $v = 27,000 \text{ kph}$



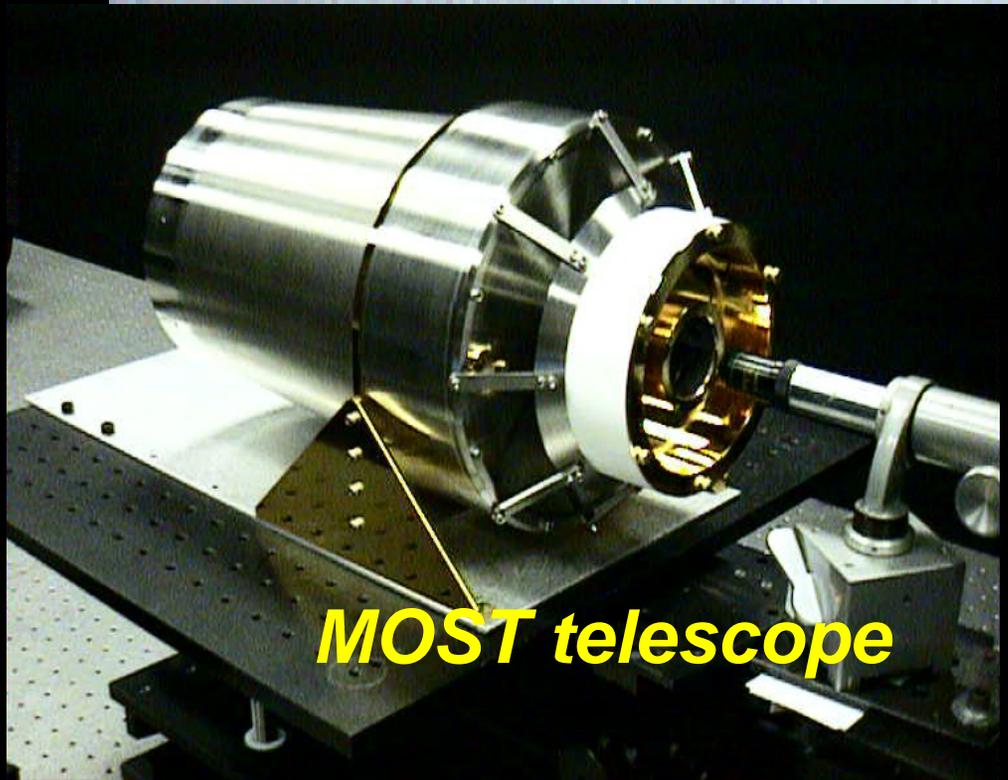
it c ll 0 of
am for
an i p
he e n
o me ag is a
u ow on
ta ue
or t w or

With act all 0 of
ample form
an imp
he he mean
o me age his a
u ow ions
tar que
or t who tory

Without practically 100% of the sample of information, it can be almost impossible to decipher the meaning of the message. This is as true for how the variations of a star or a sequence of words tells the whole story.



Galileo's telescope



MOST telescope

same scale

Canada's space telescope – MOST

An ultraprecise lightmeter

- ✓ MOST measures changes in the brightnesses of stars as small as 1 part in a million



Canada's space telescope – MOST

An ultraprecise lightmeter

- ✓ *MOST measures changes in the brightnesses of stars as small as 1 part in a million*

How sensitive is this?

If you look at the Empire State Building at night with all the lights on and all the office blinds open... you can reduce its brightness by 1 part per million by pulling a single blind down 3 cm



**The stars are alive...
...With the sound of music**



Solar symphony

Making waves

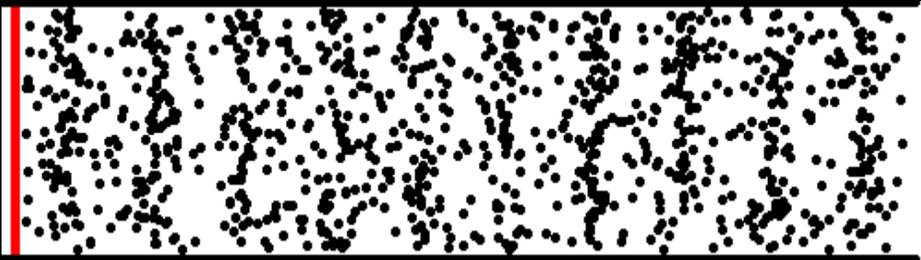
“Adore the Sun
... the shining maker of light”

*Hymn to the Sun
Hindu poem (300 BC)*

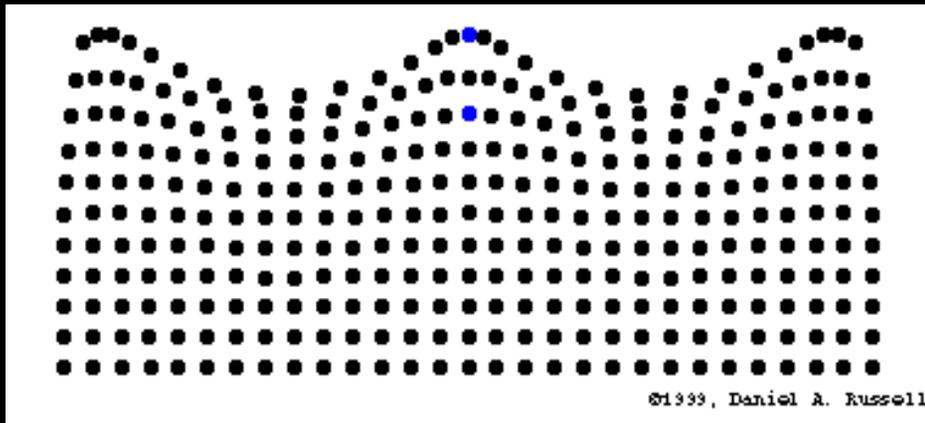


Solar symphony

Acoustic waves



Buoyancy waves

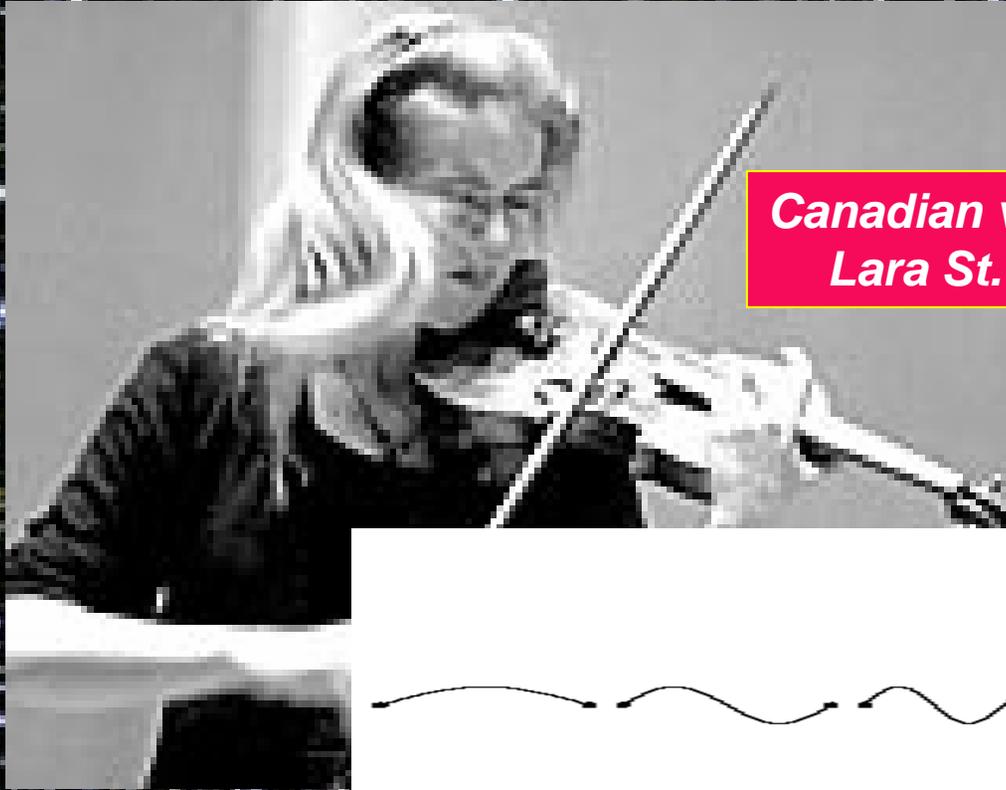


Listening to the music of the stars

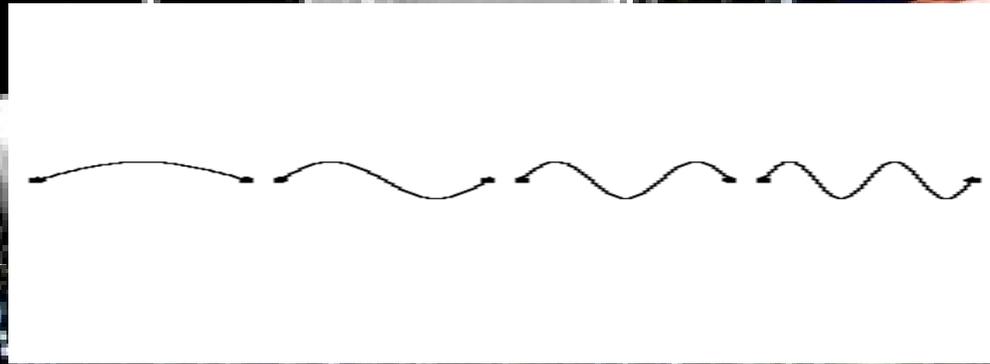
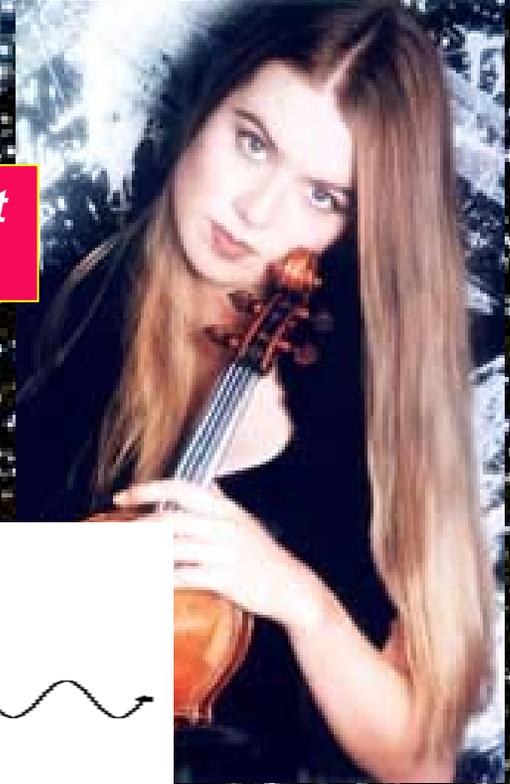
The Sun and many stars vibrate like giant gaseous bells, due to sound generated by turbulence in the gas near their surfaces.

How do you detect sound waves in a star???
Telescopes are 'deaf', due to vacuum of space.

Listening to the music of the stars



*Canadian violinist
Lara St. John*



How can a deaf person 'listen' to music???
Sound is just a combination of vibrations.

Listening to the music of the stars



How can a deaf person 'listen' to music???

Sound is just a combination of vibrations.

Listening to the music of the stars



pulsating
star in the
nightsky

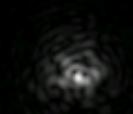


How can any telescope “listen” to a star???
Vibrations translate into light variations.

Listening to the music of the stars



twinkling
star in the
nightsky



How can any telescope “listen” to a star???
Vibrations translate into light variations.

Listening to the music of the stars



**First Nations
ceremonial
drum**

twinkling
star in the
nightsky

brightness
variations
with time
(light curve)

if you could
see the star
as a disk

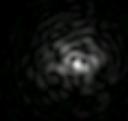


How can any telescope “listen” to a star???
Vibrations translate into light variations.

Listening to the music of the stars

- ❑ But “twinkling” of stars due to turbulence in the Earth’s atmosphere is about 100× larger than genuine oscillations in Sun-like stars
- ❑ To measure this, we need to put instruments above the atmosphere...
- ❑ ...and they need to be sensitive to vibrations with amplitudes as small as only 0.0001%

twinkling
star in the
nightsky



brightness
variations
with time
(light curve)



if you could
see the star
as a disk

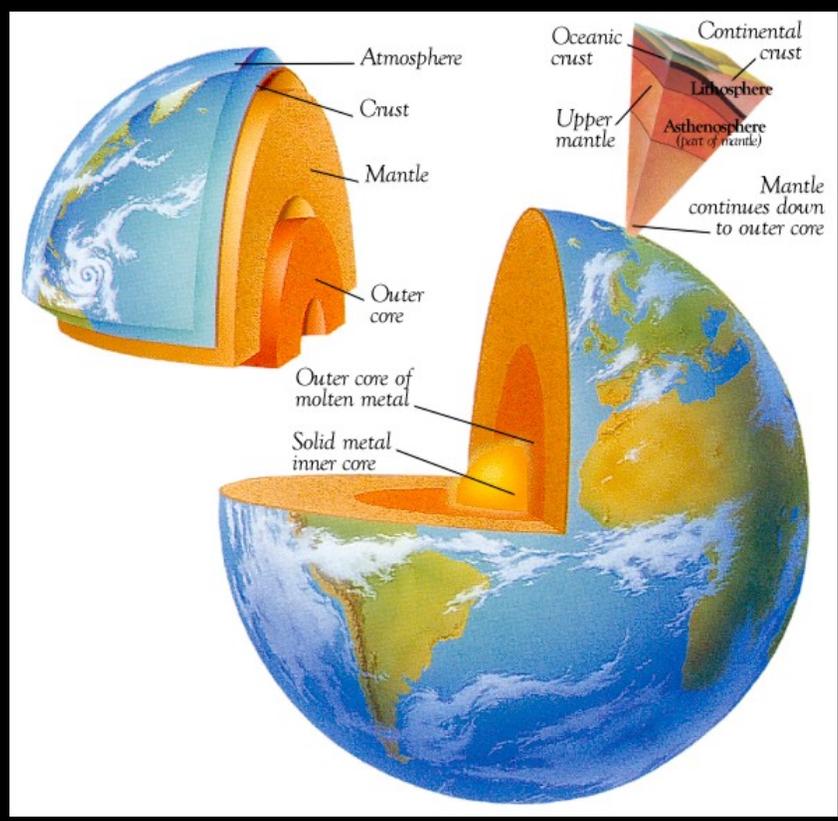


How can any telescope “listen” to a star???

Vibrations translate into light variations.

Listening to the music of stars

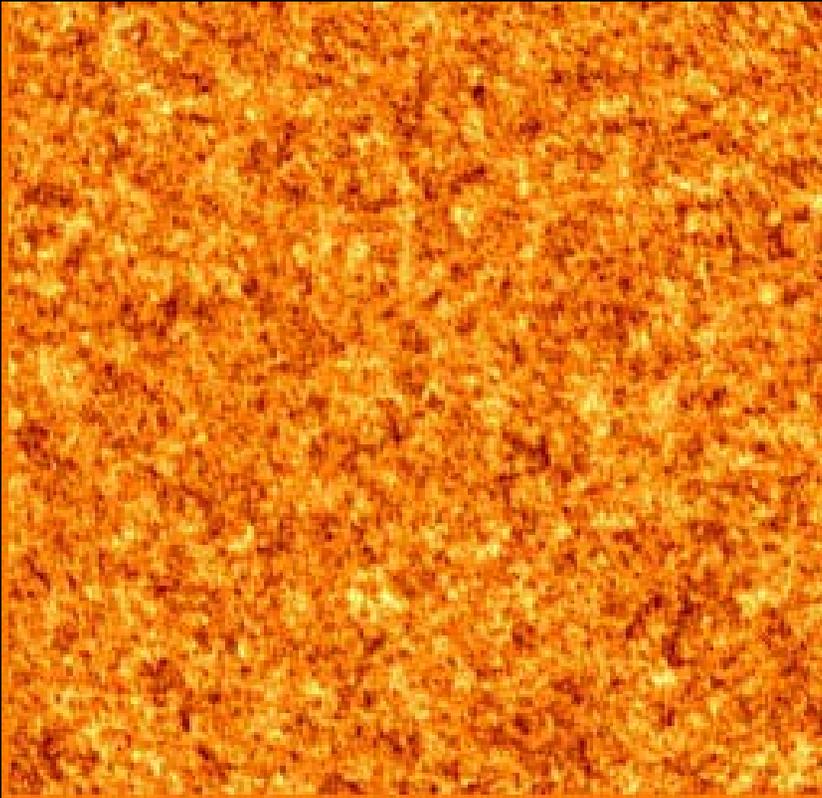
Seismology of the Earth



Seismology of the Sun and stars

Listening to the music of stars

SOHO Dopplergram

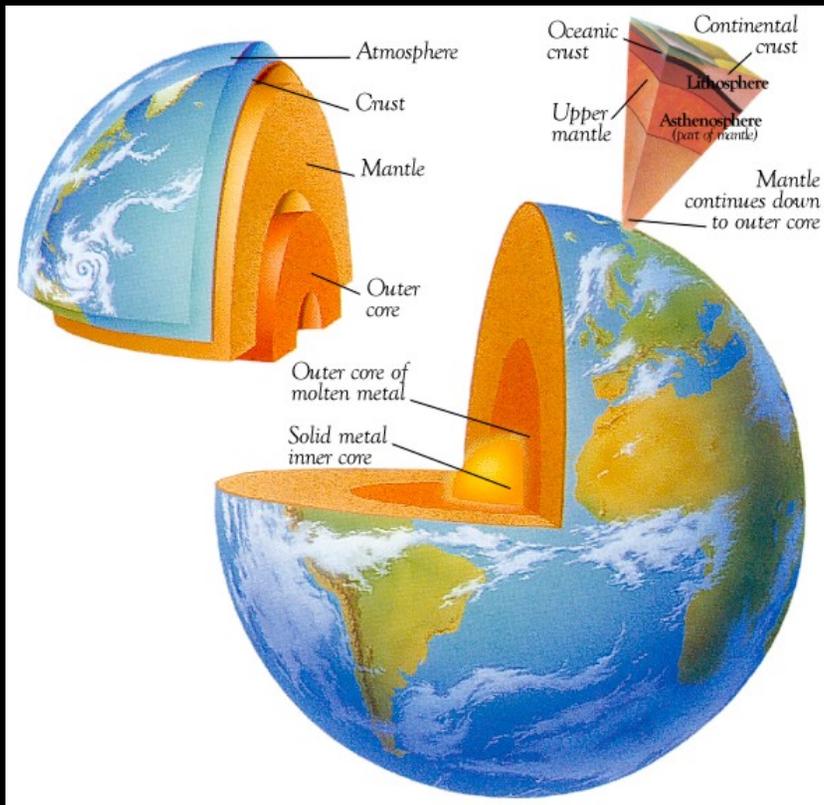


Seismology of the
Sun and stars

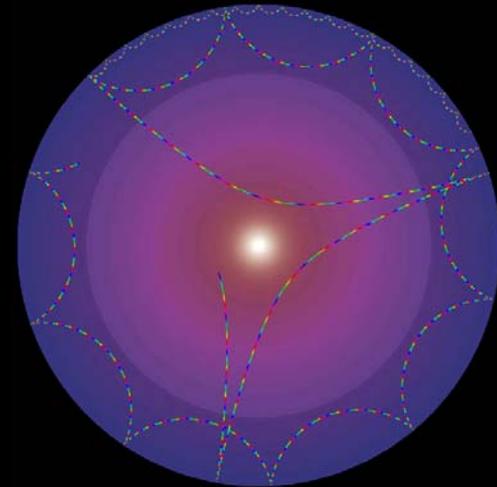


Listening to the music of stars

Seismology of the Earth



acoustic ray paths

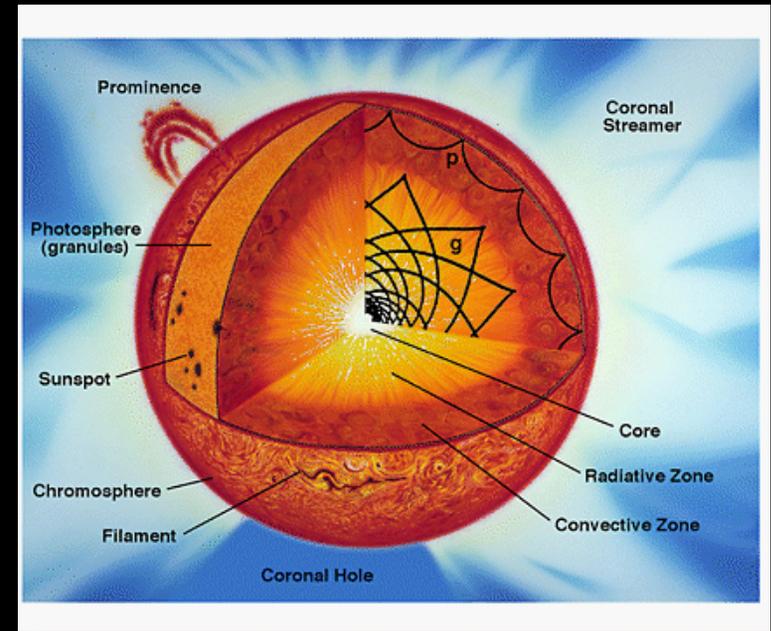
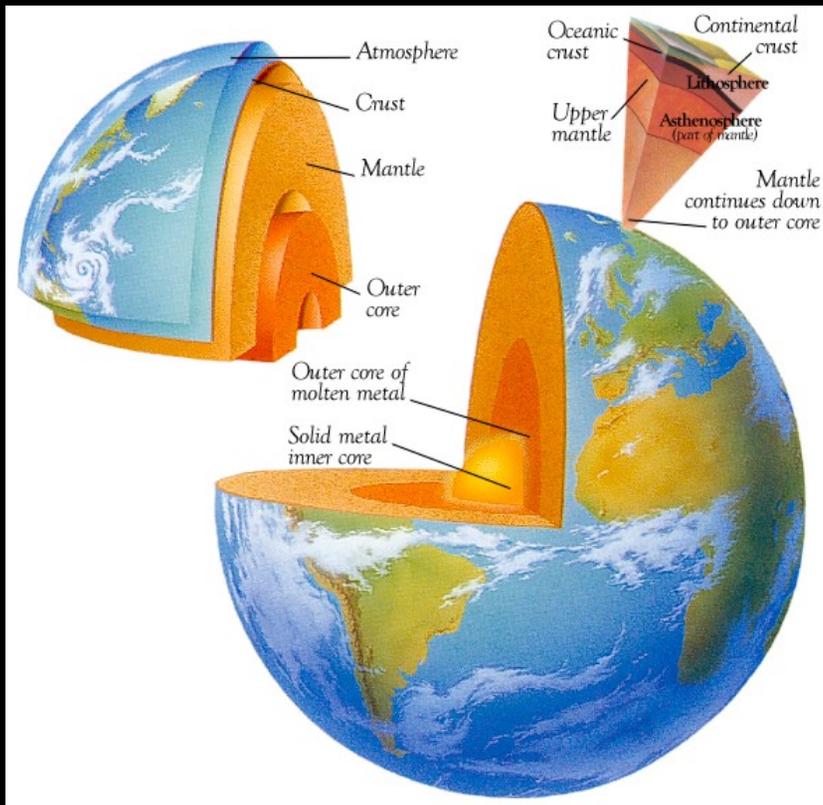


Seismology of the Sun and stars

" acoustic refraction "

Listening to the music of stars

Seismology of the Earth



Seismology of the Sun and stars

"acoustic refraction"

Acoustic refraction and Roswell

UFO sightings increase near concerts and honky-tonks!

SPACE ALIENS LOVE COUNTRY MUSIC

VISITORS from other planets may be attracted to the particular vibrations of Western melodies.



By **RANDY JEFFRIES**
Correspondent

HOUSTON, Texas — Experts have discovered a definite but baffling link between UFO activity and country music!

Newly released information indicates that an amazing number of reports of alien spacecraft sightings occur in areas where the songs of Nashville singers are being played.

"We're not sure what to make of it," says Dr. Zachary Simms, noted UFO expert, who's been investigating encounters with space aliens for more than 12 years.

"It may or may not be significant.

"But our research shows that in an incredible 68 percent of the cases where UFO sightings are actually reported, country music has been playing — at either a concert or in a so-called honky-tonk joint — within 14 miles.

sightings had in common with one another," says the 34-year-old researcher. "We didn't know exactly what we were looking for.

"We fed information into our computer from over 700 reports of alien activity over the last 15 years — everything from what time of day the sighting occurred to what color clothes the witnesses were wearing.

"We even logged in what thoughts the people were thinking just before they encountered the aliens.

"The only factor that came up with regularity was country music."

Amazingly, Dr. Simms' study included sightings not only in the U.S. but Peru, Australia and Africa as well. And even in those foreign places, American country mu-



UFO expert, Dr. Zachary Simms,



Weekly World News
March 1998

Roswell Daily Record
1947



Acoustic refraction and Roswell

Project Mogul

high-altitude
balloon with
sensitive
microphone
in payload

above-ground
nuclear test

sound waves refracted by high-altitude T inversions
(a "sound pipe")



New Mexico



Soviet Union

Acoustic refraction and Roswell

Project Mogul

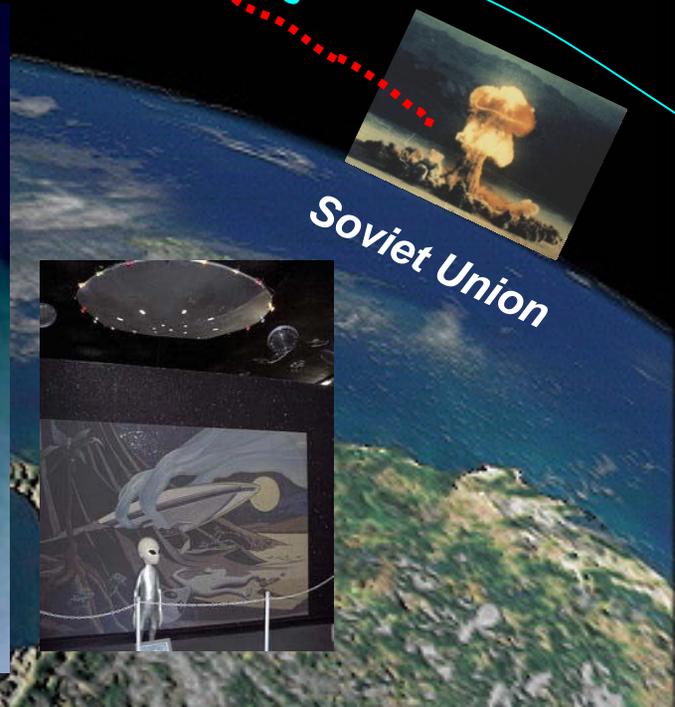
high-altitude balloon with sensitive microphone in payload

above-ground nuclear test

sound waves refracted by high-altitude T inversions (a "sound pipe")



New Mexico



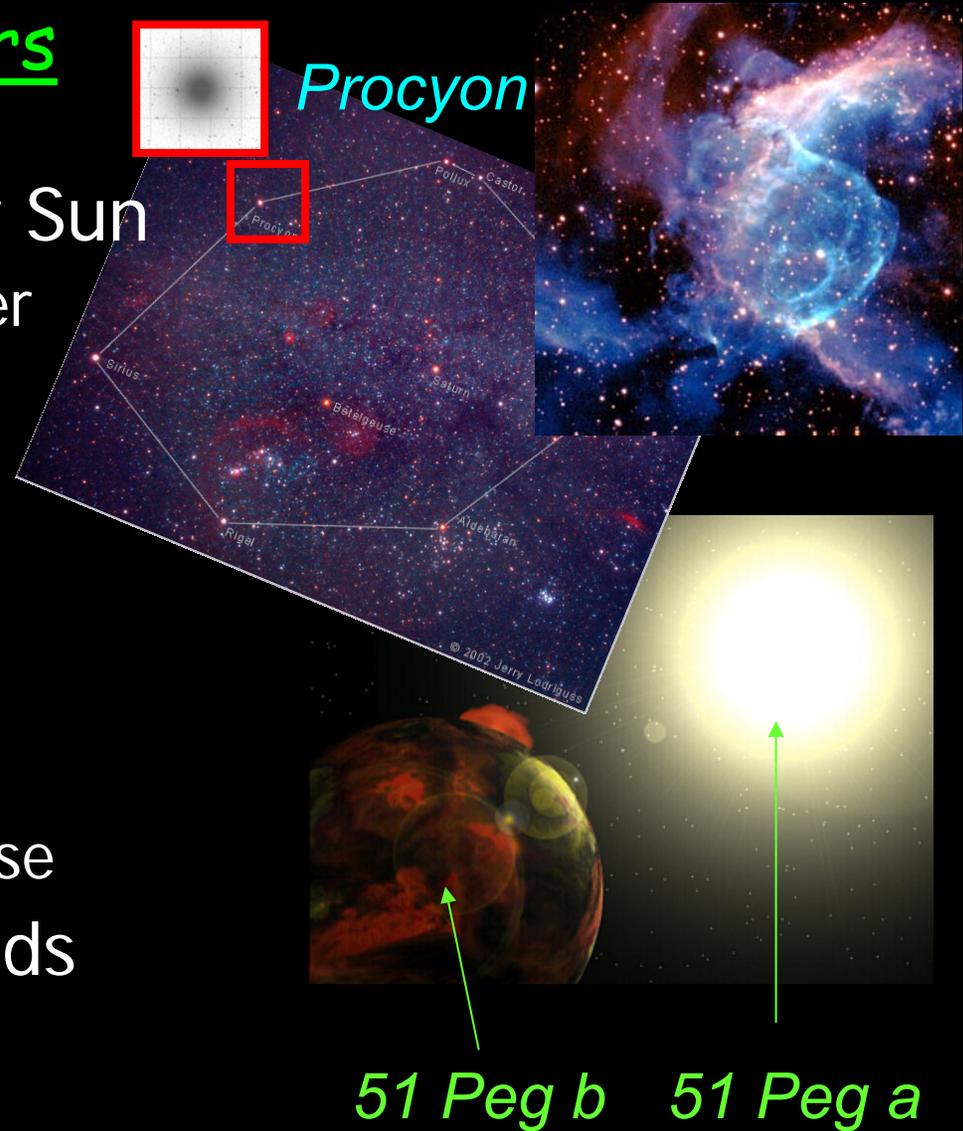
Soviet Union



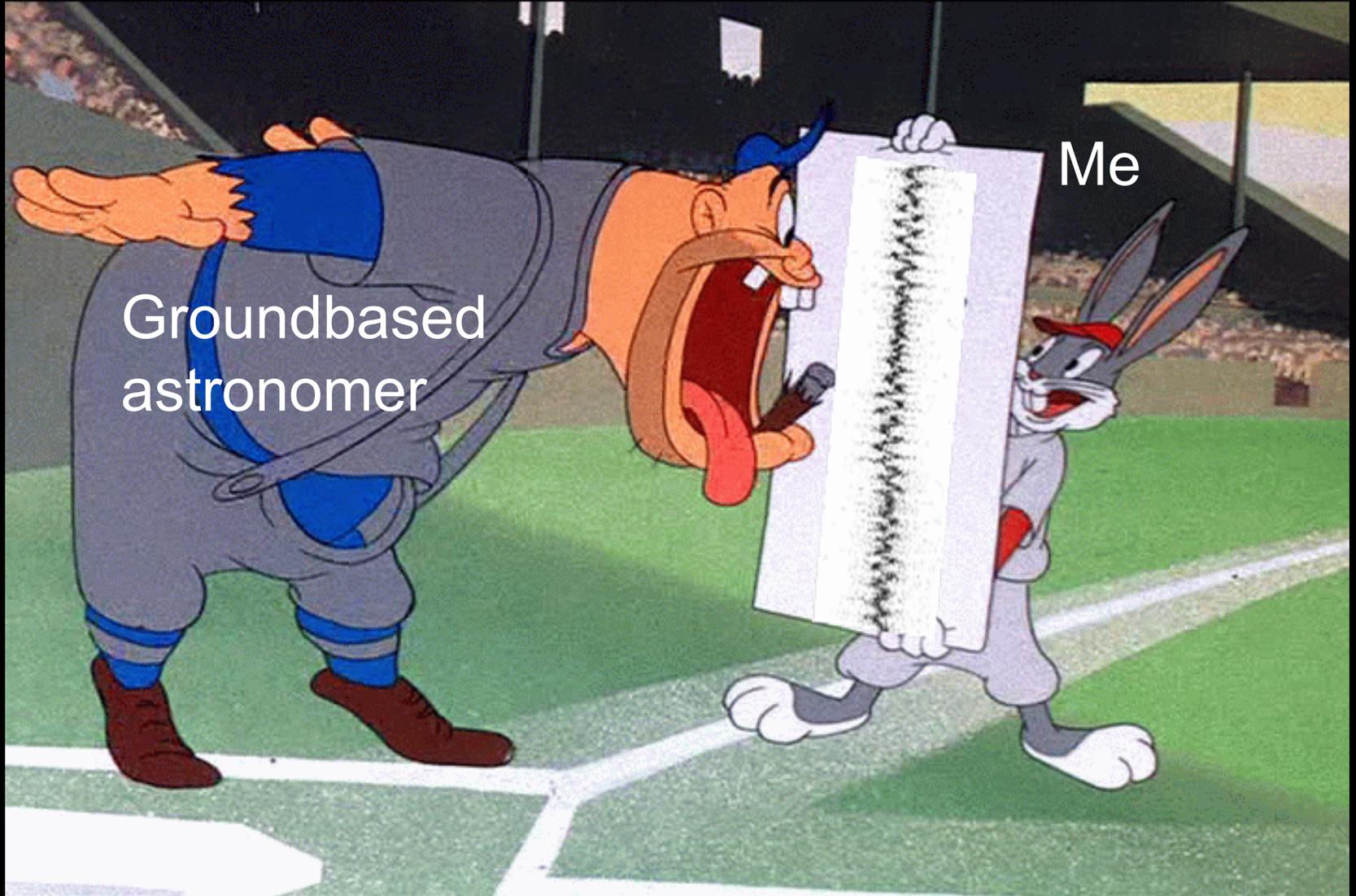
MOST Science

microvariability in stars

- Probing stars like our Sun
 - Sun's relatives at other stages in their lives
 - What was Sun like when life began on Earth?
- ancient stars in the solar neighbourhood
 - limit on age of Universe
- mysterious alien worlds around other stars



MOST Science



Groundbased astronomer

Me

Variety is the spice of life

and sweetness

Italian gelateria

Lime

Cheddar

Berry

Vegemite

Pepper

Melon

Baileys

Tiramisu

Dill Pickle

Banana

Chocolate

Vanilla

Garlic

Cherry

Tutti Frutti



Casa Gelato, Vancouver

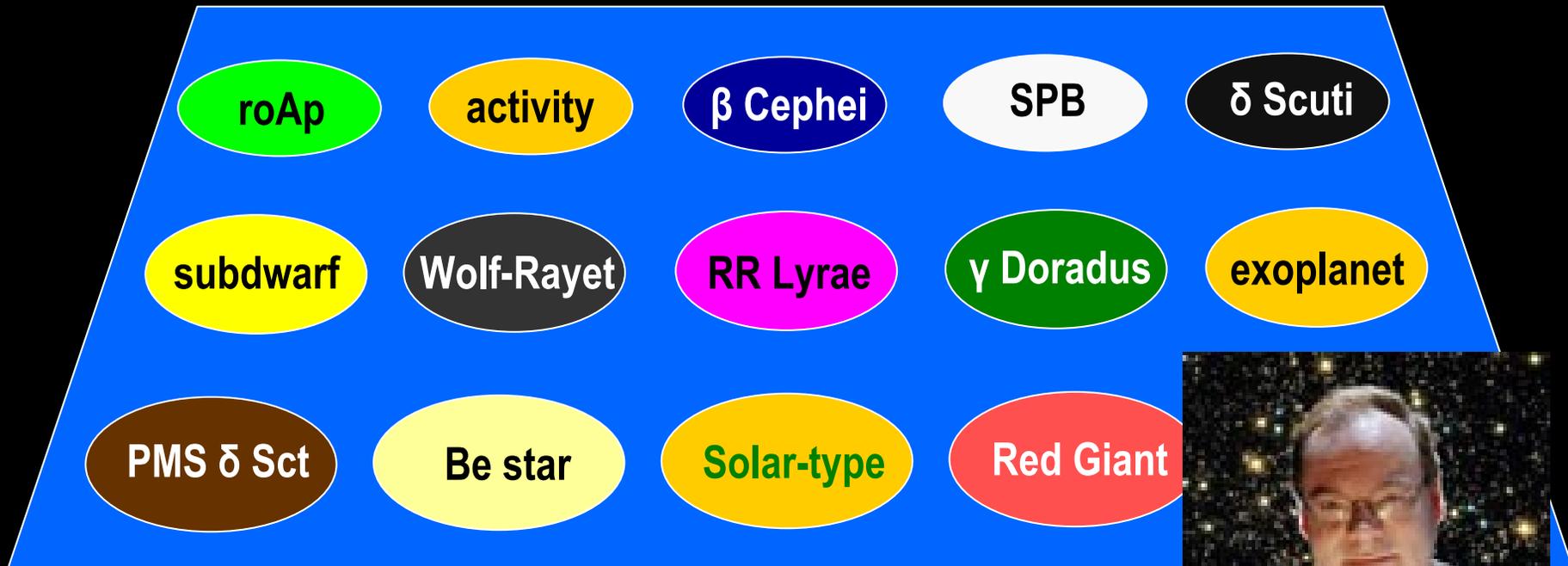
700 flavours

198 on offer at any one time



Variety is the spice of astrophysics *and sweetness*

MOST stellaria



50 Primary Science Targets
5 Commissioning Targets
~2000 Direct Imaging & Guide Field Targets

Ultrasound of stellar embryos

NGC 2264

"Christmas Tree Cluster"

distance ~ 2100 light years

age ~ 8 million years

*NOTE: Sun is 4.5 billion years old,
equivalent to a middle-aged adult star*

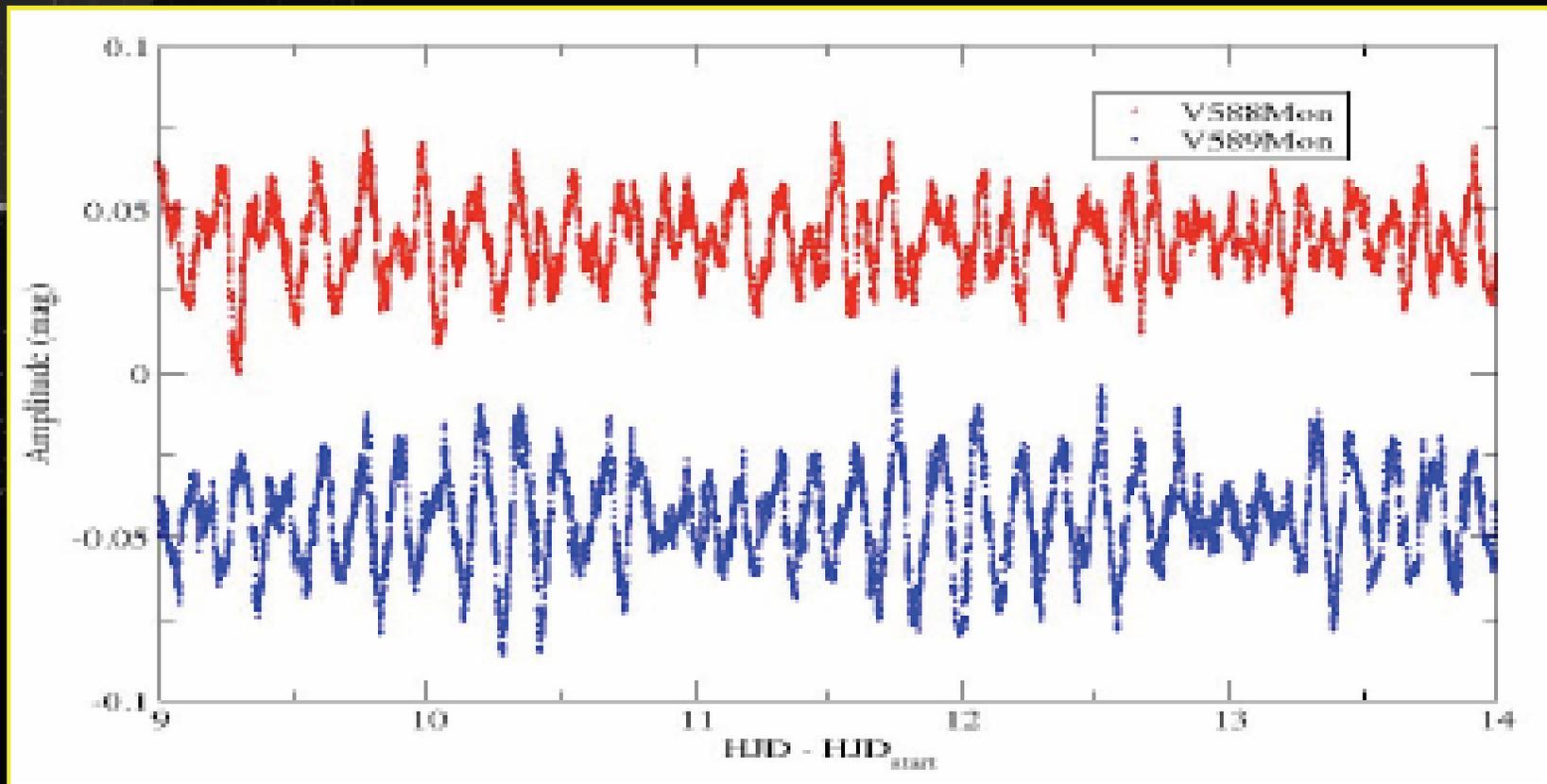
V589 Mon



Ultrasound of stellar embryos

NGC 2264

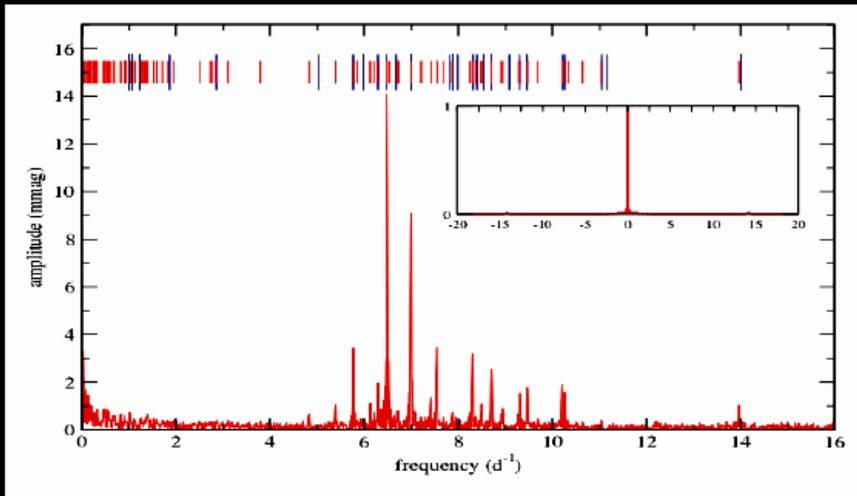
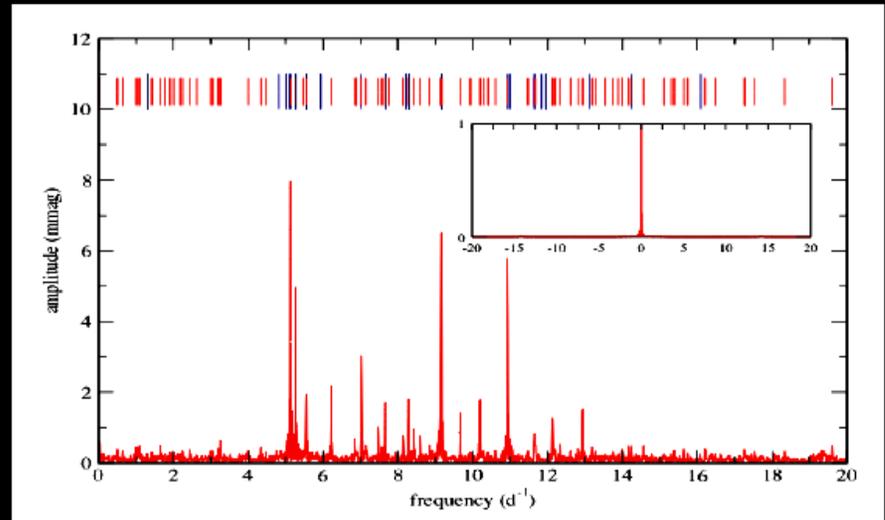
5 days of the 'heartbeats' of baby stars



Ultrasound of stellar embryos

NGC 2264

123 frequencies
in MOST data



98 frequencies
in MOST data

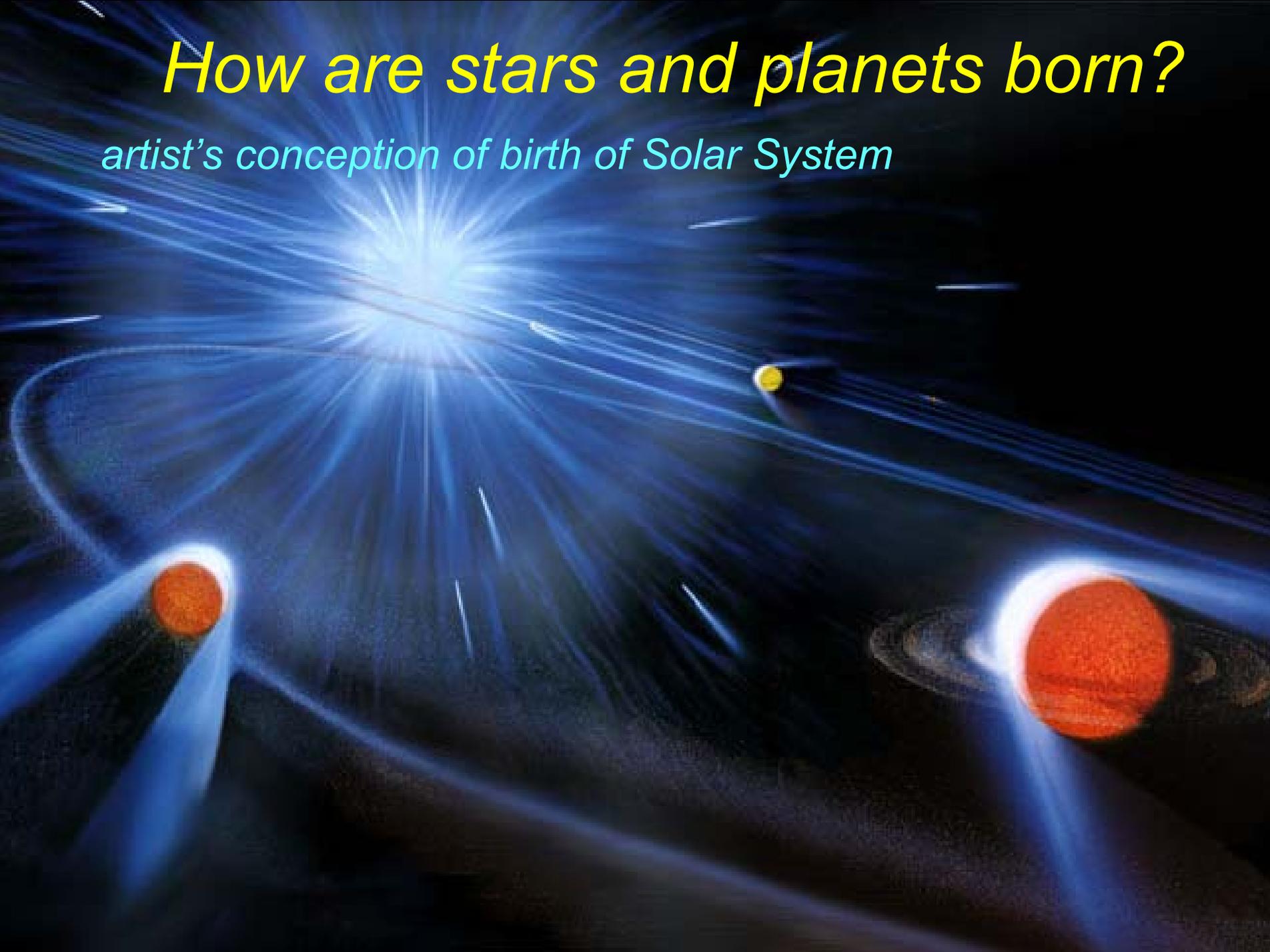
How are stars and planets born?

artist's conception of birth of Solar System



How are stars and planets born?

artist's conception of birth of Solar System



MOST explores alien worlds

*artist's conception of extrasolar planet
HD 209458*

*MOST is the
only instrument
currently capable
of detecting the
faint light reflected
from a planet outside
of our Solar System*



Light – More than meets the eye

How does a speeder get a ticket?



CANADA
Province of Ontario
CITY OF OTTAWA
To wit,
22/

SUMMONS TO THE DEFENDANT UPON INFORMATION OR COMPLAINT

To *Lady Laurier*
OF THE CITY OF OTTAWA.

Whereas, information hath been laid before the undersigned one of His Majesty's Justices of the Peace in and for the said City of Ottawa, FOR THAT YOU the said *Lady Laurier*

on the *9th* day of *February* A.D. *1960*,
at the City of Ottawa aforesaid, did unlawfully *upon a public highway, to wit, Bank Street in said City, at a greater rate of speed than ten miles an hour,*
contrary to the form of the Statute in such case made and provided:

THESE ARE THEREFORE to command you in His Majesty's name to be and appear on *Wednesday, the 16th day of February* A.D. *1960*, at ten o'clock in the forenoon, before me at the Police Court in the said City of Ottawa, or before such other Justice or Justices of the Peace for the said City of Ottawa, as shall then be there, to answer to the said information and to be further dealt with according to law. Herein fail not.

Given under my hand and seal this *14th* day of *February* in the year of our Lord one thousand nine hundred and *ten*, at the City of Ottawa, aforesaid

Sgt. W. P. Lett
J. P. OTTAWA.

Police ticket form with handwritten details:

- Vehicle No. [redacted]
- Driver's Name [redacted]
- Officer's Name [redacted]
- Section [redacted]
- Charge: **EXCESSIVE SPEED**
- Speed: **60** (limit **50**)
- City: **OTTAWA**
- Magistrate: **CONTACT DISTRICT COURT - 1st FLOOR, 325 COURT STREET, SAULT STE. MARIE, ONT. L7X 6S6**

Light – More than meets the eye

How does a speeder get a ticket?

The world's first speeding ticket?

This citation was issued to Lady Laurier (wife of the Prime Minister) in Ottawa in 1910 for driving a motor vehicle faster than the speed limit of 10 miles per hour (17 kph)!

CANADA:
Province of Ontario,
CITY OF OTTAWA.
To wit,

22-
SUMMONS TO THE DEFENDANT UPON INFORMATION OR COMPLAINT
To *Lady Laurier* OF THE CITY OF OTTAWA.

Whereas, information hath been laid before the undersigned one of His Majesty's Justices of the Peace in and for the said City of Ottawa, FOR THAT YOU the said *Lady Laurier*

on the *8th* day of *February* A.D. *1910*,
at the City of Ottawa aforesaid, did unlawfully *run a motor vehicle upon a public highway, to wit, Bank street in said City, at a greater rate of speed than ten miles an hour.* –
contrary to the form of the Statute in such case made and provided:

THESE ARE THEREFORE to command you in His Majesty's name to be and appear on *Wednesday* the *16th* day of *February* A.D. *1910*, at ten o'clock in the forenoon, before me at the Police Court in the said City of Ottawa, or before such other Justice or Justices of the Peace for the said City of Ottawa, as shall then be there, to answer to the said information and to be further dealt with according to law. Herein fail not.

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Sgd. W.P. Lett
J.P. Ottawa.

Light – More than meets the eye

How does a speeder get a ticket?



CANADA
Province of Ontario,
CITY OF OTTAWA,
To *Lady Laurier*
OF THE CITY OF OTTAWA.

Whereas, information hath been laid before the undersigned one of His Majesty's Justices of the Peace in and for the said City of Ottawa, FOR THAT YOU the said *Lady Laurier*

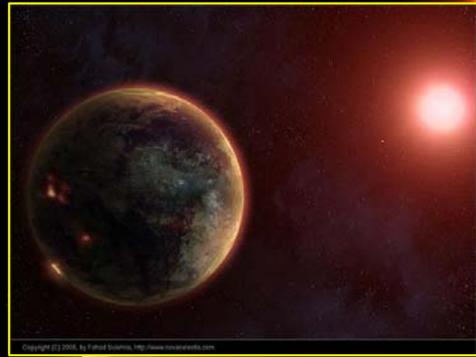
on the *9th* day of *February*, A.D. 19*99*,
at the City of Ottawa aforesaid, did unlawfully *drive a motor vehicle upon a public highway, to wit, Bank Street in said City, at a greater rate of speed than ten miles an hour*;
— contrary to the Statute in such case made and provided:

THESE ARE THEREFORE to command you in His Majesty's name to be and appear on *Wednesday, the 16th day of February*, A.D. 19*99*, at ten o'clock in the forenoon, before me at the Police Court in the said City of Ottawa, or before such other Justice or Justices of the Peace for the said City of Ottawa, as shall then be there, to answer to the said information and to be further dealt with according to law. Herein fail not.

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Sgt. W. D. Lett

2 P. Ottawa.

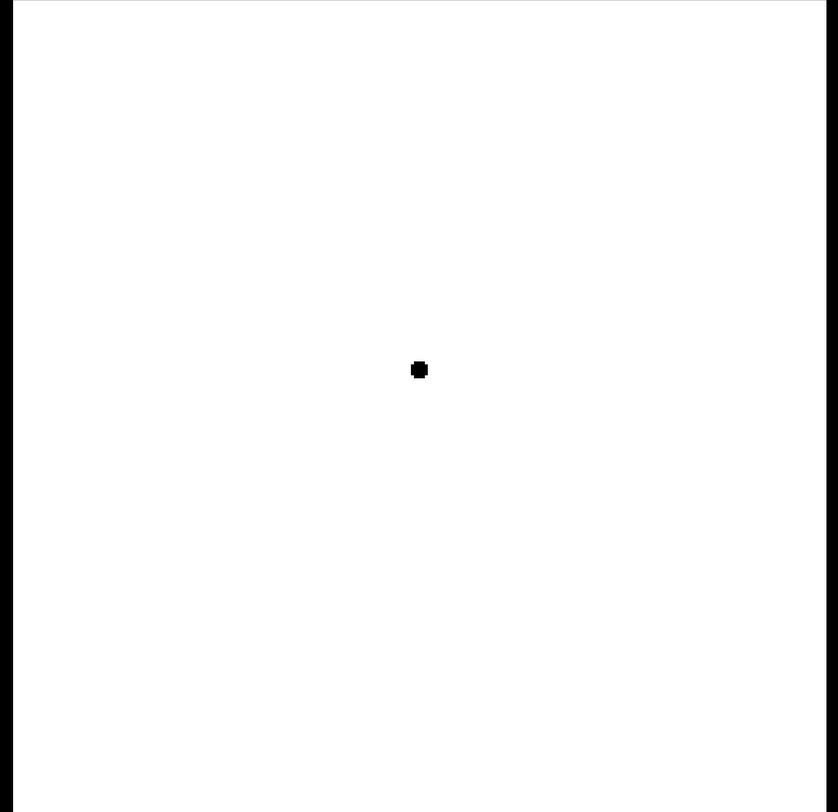


And an astronomer find an alien planet?

Light – More than meets the eye

The Doppler Effect

If a source of waves is not moving, then the waves radiate symmetrically in all directions with the same wavelength

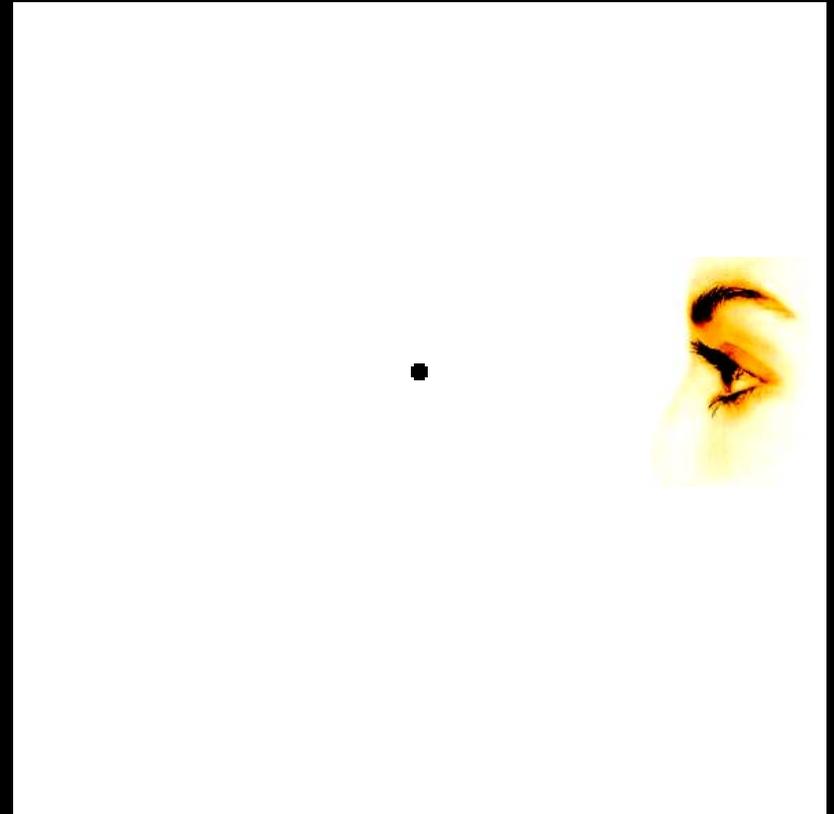


Light – More than meets the eye

The Doppler Effect

If a source of waves is not moving, then the waves radiate symmetrically in all directions with the same wavelength

If it's moving towards you, then the wavecrests passing you are closer together and the wavelength you measure is reduced

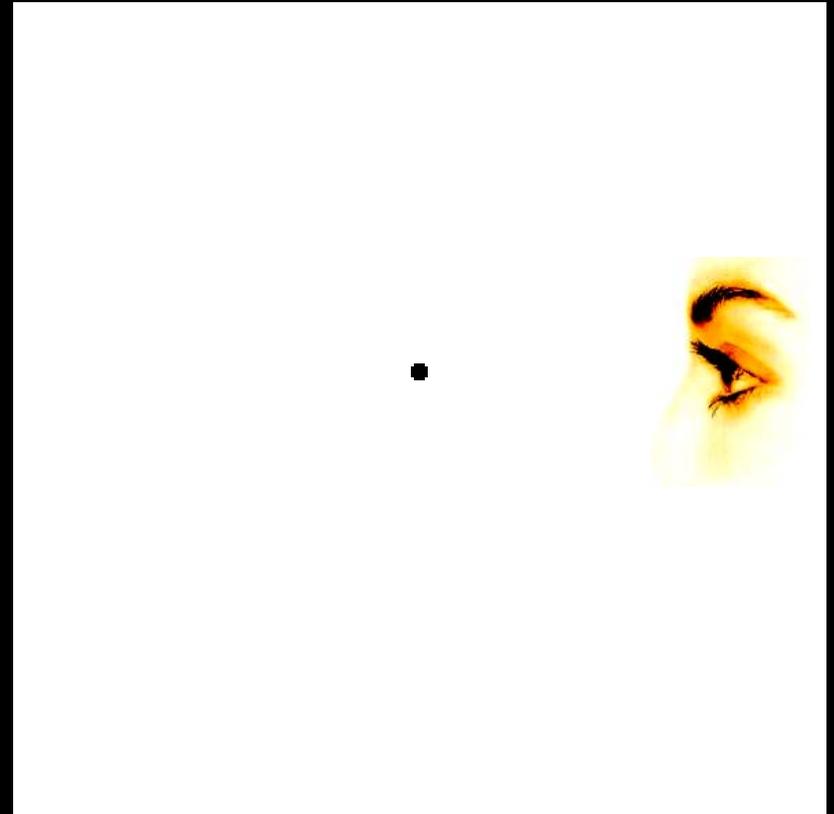


Light – More than meets the eye

The Doppler Effect

If a source of waves is not moving, then the waves radiate symmetrically in all directions with the same wavelength

If it's moving away from you, then the wavecrests passing you are closer together and the wavelength you measure is increased

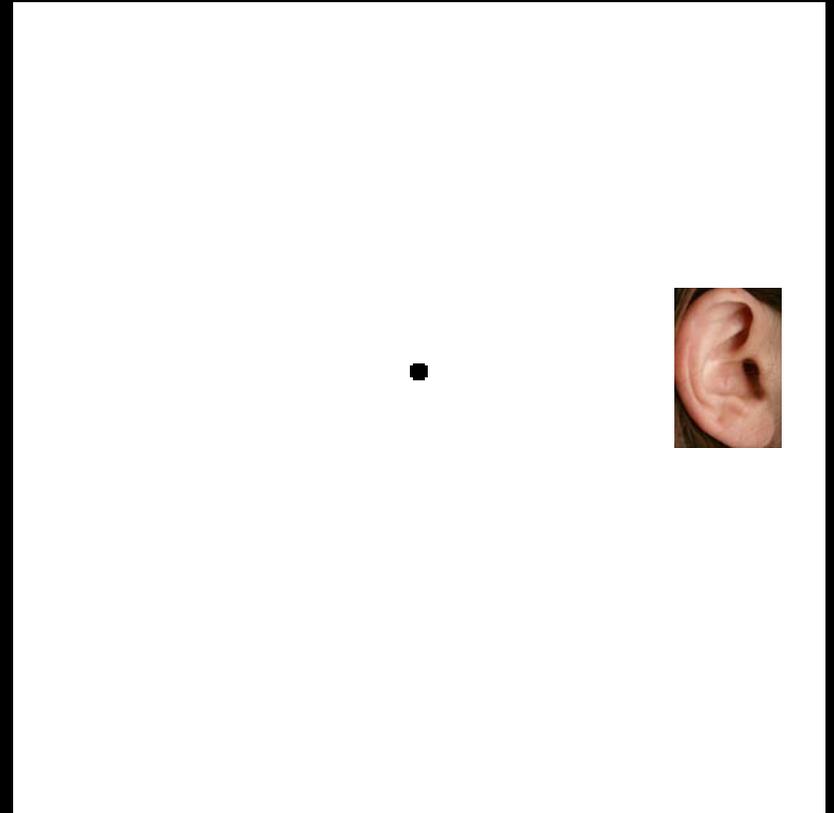


Light – More than meets the eye

The Doppler Effect

If a source of waves is not moving, then the waves radiate symmetrically in all directions with the same wavelength

If it's emitting sound waves and moving at the speed of sound, then its velocity is called *Mach 1*



Light – More than meets the eye



*An actual video of a jet and the surrounding air
as the plane breaks the sound barrier*

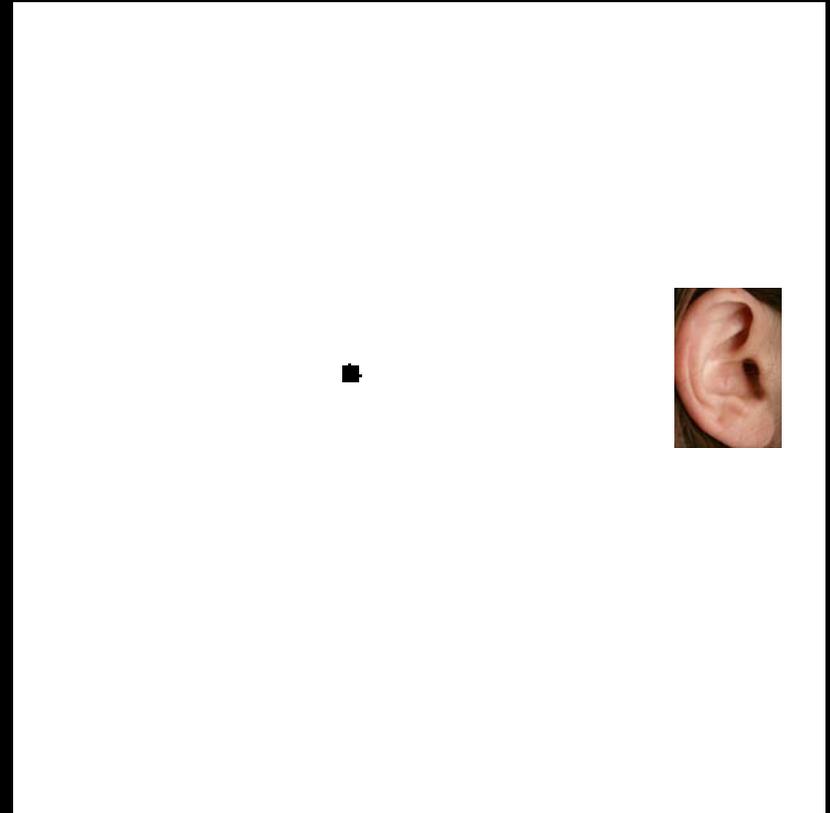
Light – More than meets the eye

The Doppler Effect

If a source of waves is not moving, then the waves radiate symmetrically in all directions with the same wavelength

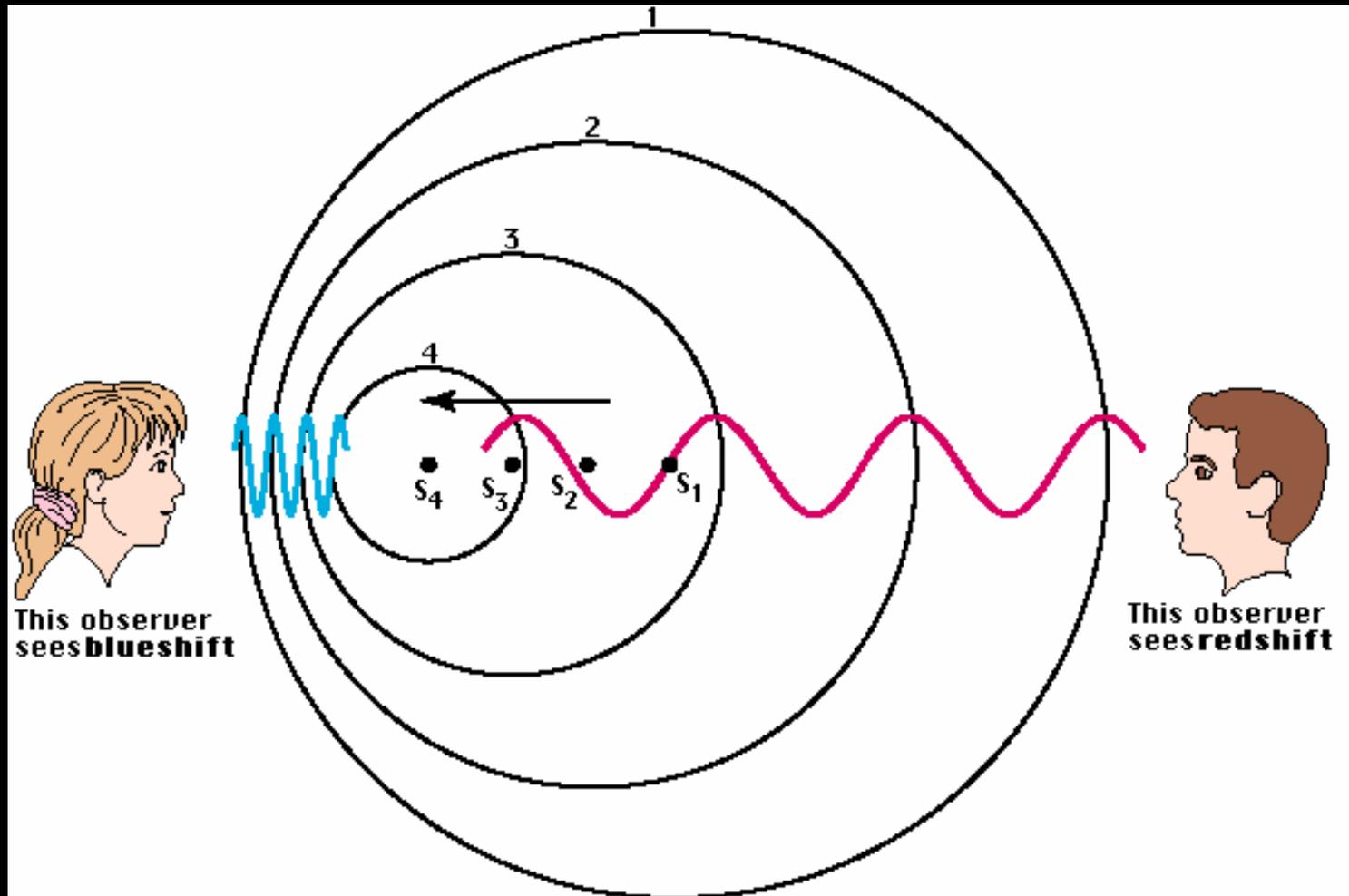
If it's travelling faster than the speed of sound, the source is *supersonic*

Nothing can travel faster than the speed of light and be *superluminal*



Light – More than meets the eye

The Doppler Effect



Light – More than meets the eye

The Doppler Effect

If the speed is not relativistic
(a significant fraction of the speed of light)
then the Doppler shift is given by

$$\frac{\Delta\lambda}{\lambda} = \frac{v_{\text{rad}}}{c}$$

where

λ is the emitted or *rest wavelength*

v_{rad} is positive

if the source is moving away

and negative if moving toward you

$$\Delta\lambda = (\lambda_{\text{observed}} - \lambda_{\text{rest}})$$

v_{rad} = *radial velocity*

and

c = *speed of light* $\approx 300,000$ km/s

Light – More than meets the eye

Drivers seem to know about the Doppler Effect



Light – More than meets the eye

Drivers seem to know about the Doppler Effect



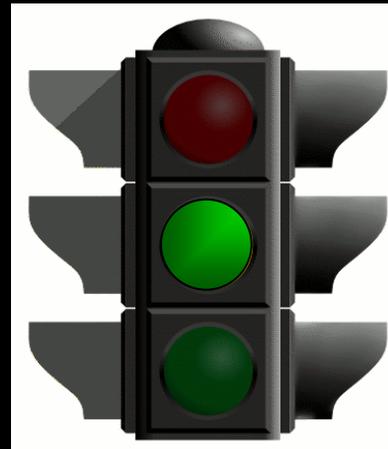
Light – More than meets the eye

Drivers seem to know about the Doppler Effect

In my experience, all drivers
– everywhere in the world –
hit the gas pedal as they
approach an amber light

They must be remembering the
Doppler Effect and realising
that if they go fast enough,
they can shift the colour
of the light from **yellow**
to **green** and go through
the intersection legally

Could this work?

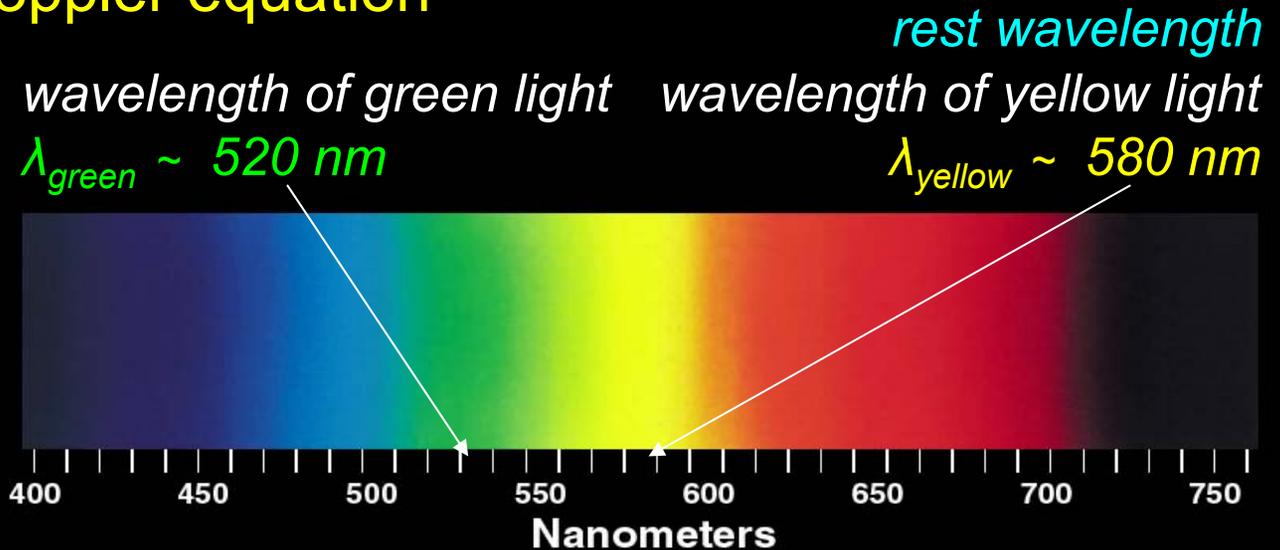


Light – More than meets the eye

Do drivers know about the Doppler Effect?

Let's apply the Doppler equation and find out.

$$\frac{\Delta\lambda}{\lambda} = \frac{v_{\text{rad}}}{c}$$



$$\Delta\lambda = (\lambda_{\text{observed}} - \lambda_{\text{rest}}) = 520 - 580 = -60 \text{ nm}$$

$$c = \text{speed of light} \approx 3 \times 10^8 \text{ m/s}$$

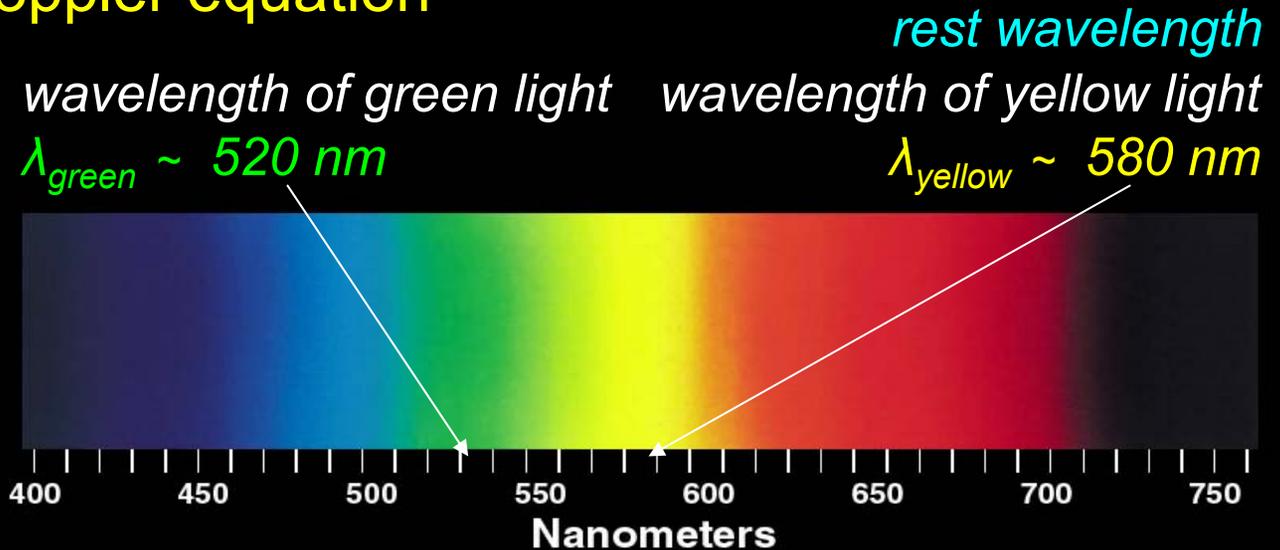
$$v_{\text{rad}} = (\Delta\lambda / \lambda) \times c \approx (-60 / 580) \times (3 \times 10^8 \text{ m/s})$$
$$\approx 3.1 \times 10^7 \text{ m/s}$$

Light – More than meets the eye

Do drivers know about the Doppler Effect?

Let's apply the Doppler equation and find out.

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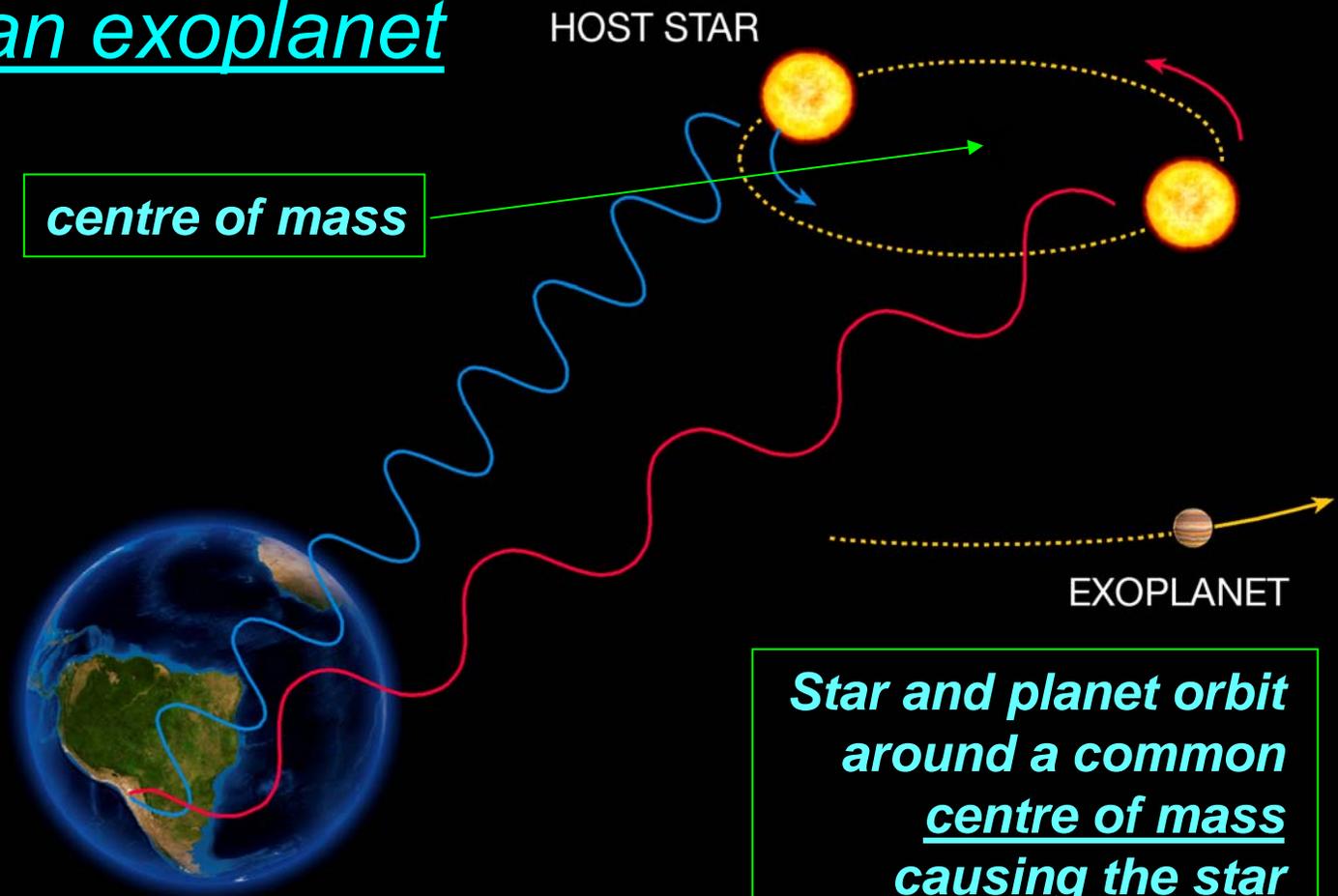
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$$v_{\text{rad}} = (\Delta\lambda / \lambda) \times c \approx (-60 / 580) \times (3 \times 10^8 \text{ m/s})$$
$$\approx 3.1 \times 10^7 \text{ m/s} \approx \underline{11 \text{ million kph!!}}$$

Light – More than meets the eye

Detecting an exoplanet



centre of mass

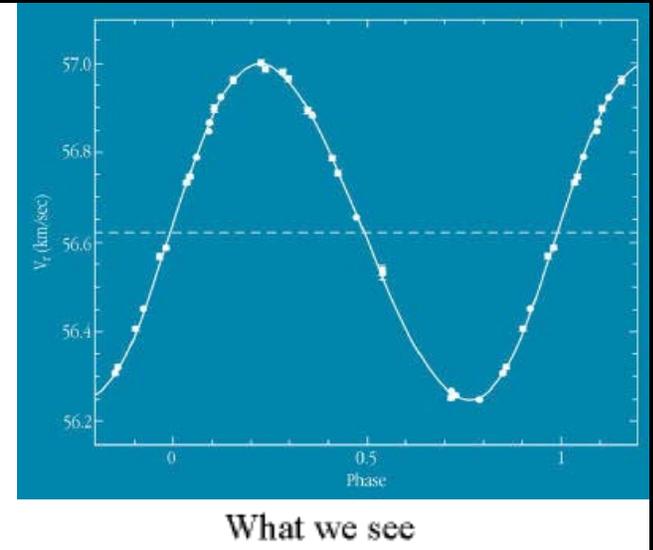
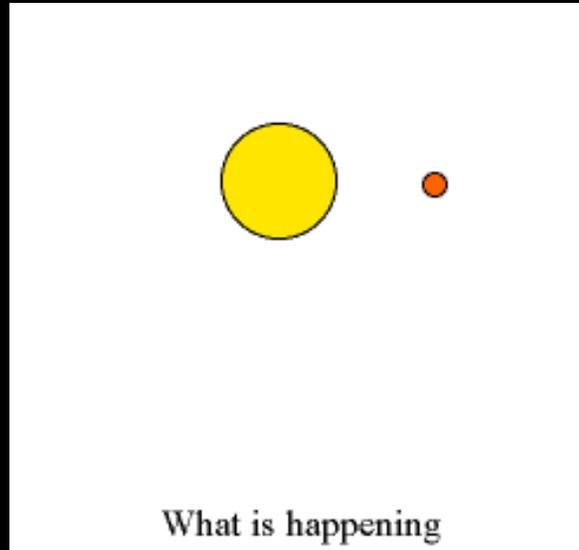
HOST STAR

EXOPLANET

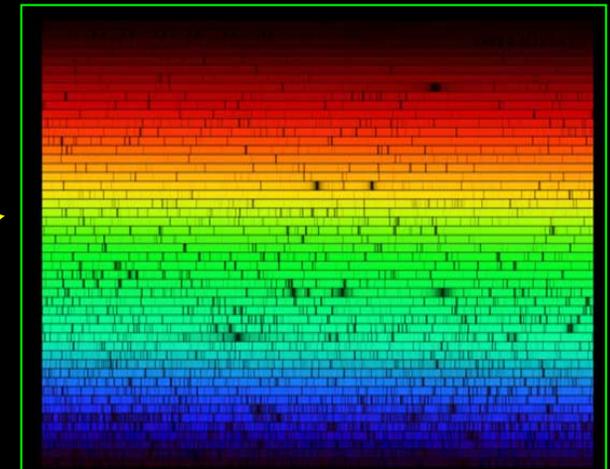
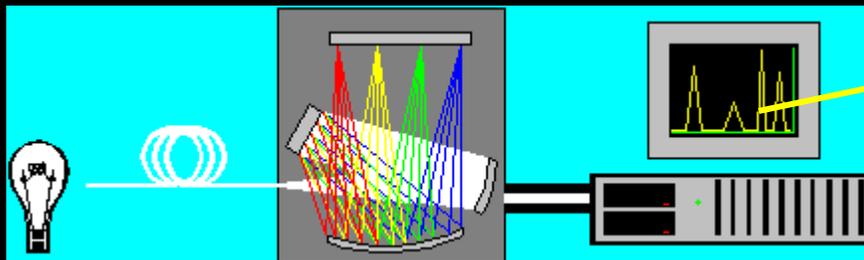
Star and planet orbit around a common centre of mass causing the star to 'wobble' with the same period as the unseen planet

Light – More than meets the eye

© Nick Strobel
astronomynotes.com

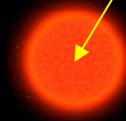
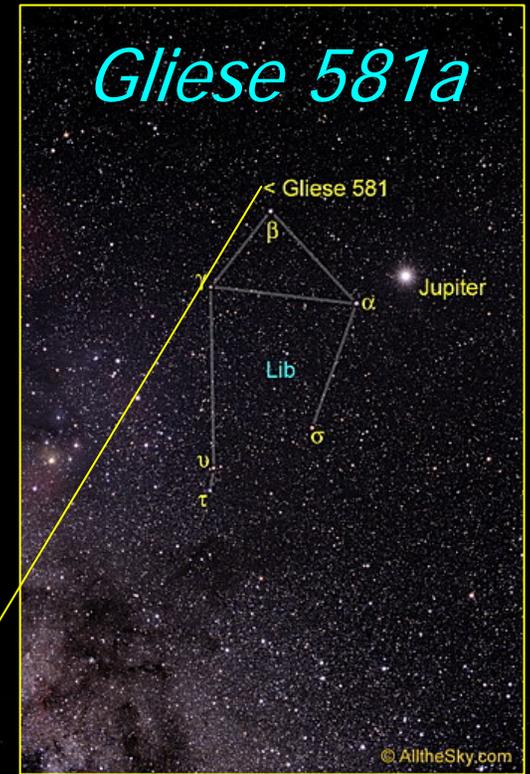


spectrum



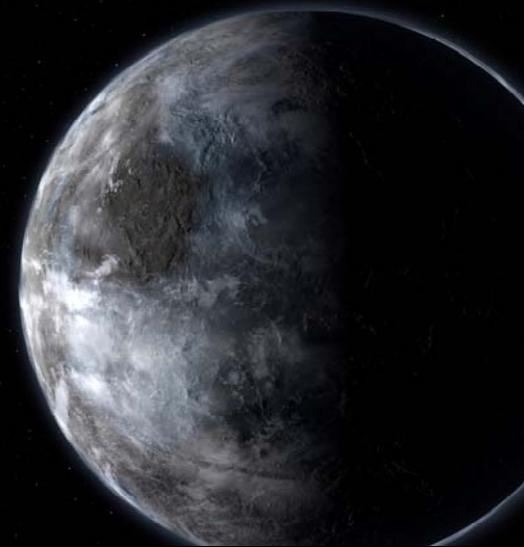
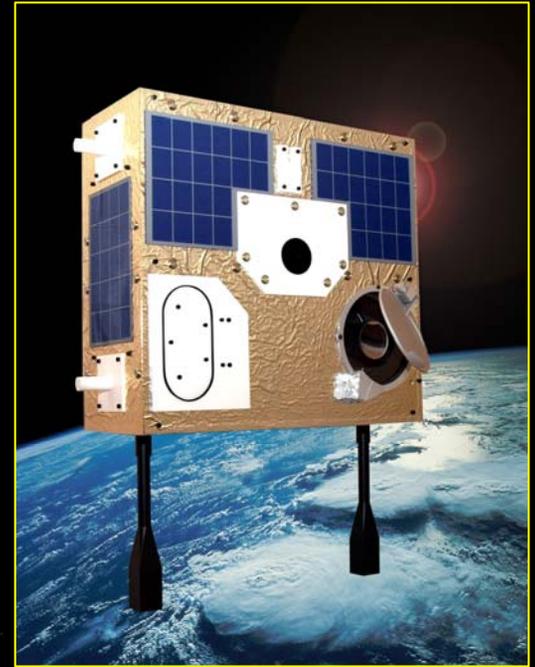
A habitable world?

- ✓ Swiss astronomers discovered three planets around a dim red dwarf
 - one of these planets may be in the habitable zone



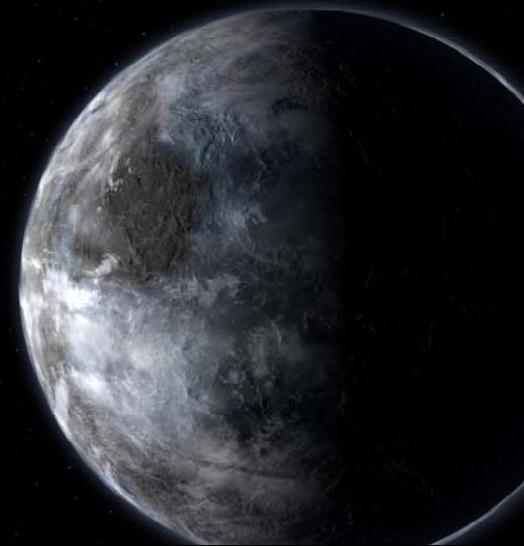
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 - *one of these planets may be in the habitable zone*
- ✓ *Canada's **MOST** space telescope put this planetary system under a stakeout for eight weeks*



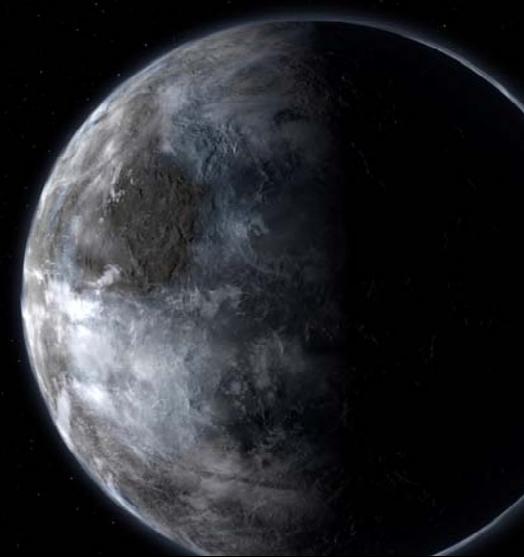
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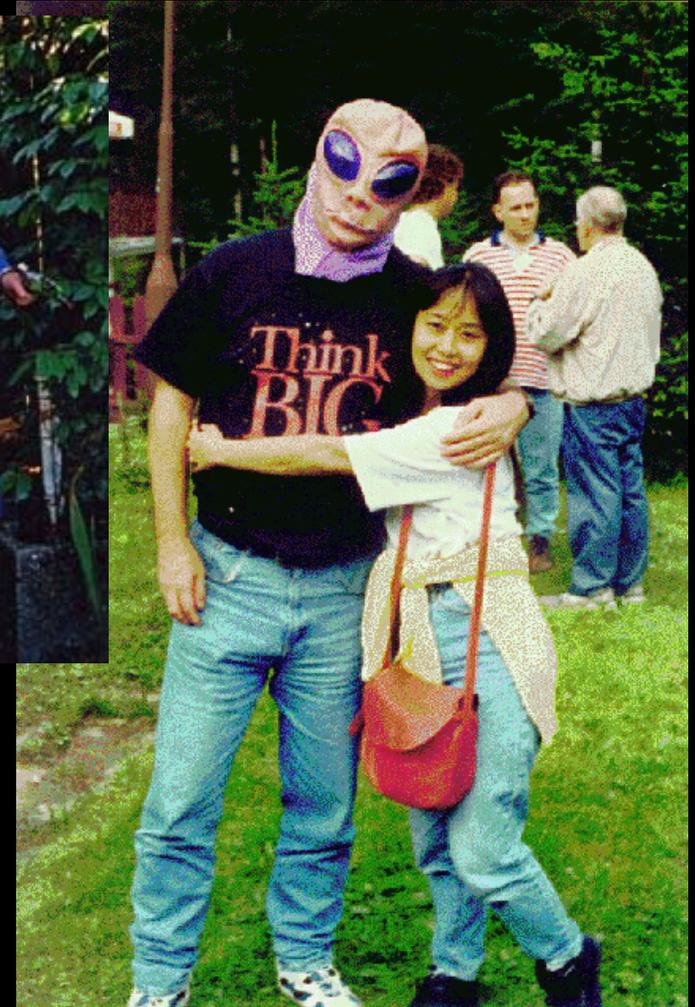
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 - *one of these planets may be in the habitable zone*
- ✓ *Canada's **MOST** space telescope put this planetary system under a stakeout for eight weeks*
- ✓ *The results were boring*
- ✓ *“Boring” is good for life*
The red dwarf star is old and stable – conditions favourable for complex life



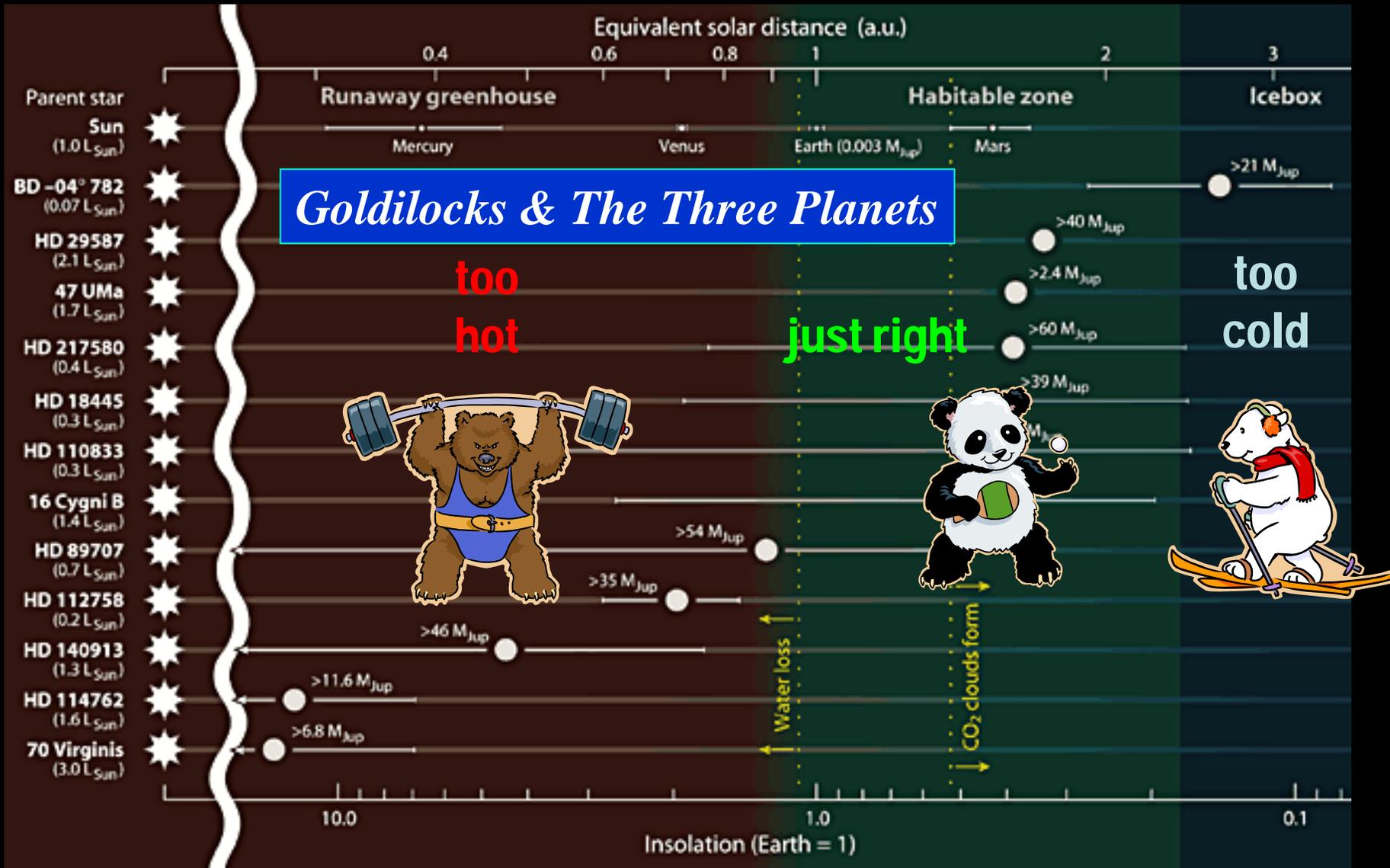
Habitable exoplanets?

The question of life out there: Is it an X File?

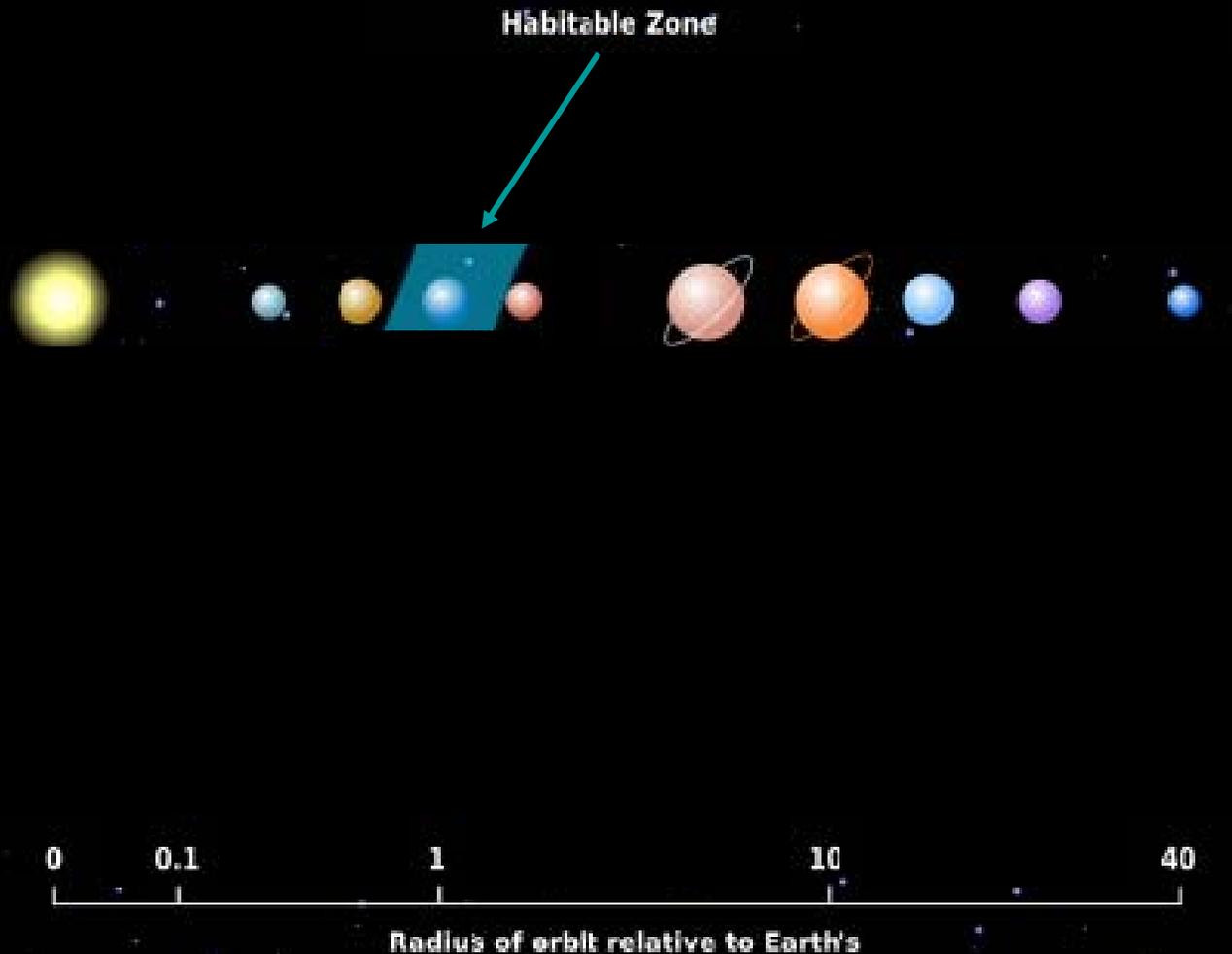


Habitable exoplanets?

The question of life out there: Or a fairy tale?



Habitable exoplanets?



Shadow play in our Solar System

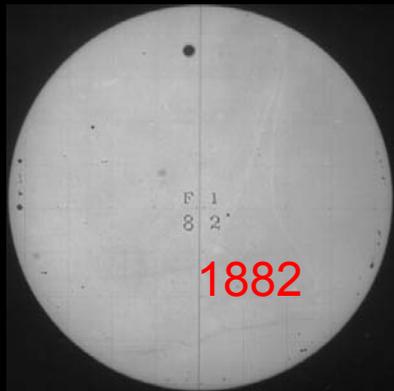


Shadow play in our Solar System



Shadow play in our Solar System

Transiting airplane



The most recent transit
of Venus occurred on
8 June 2004
The last one before that was in
1882 so there was no human
alive in 2004 that had ever
seen a transit of Venus



Shadow play in our Solar System

Transiting planet

2012 Transit of Venus

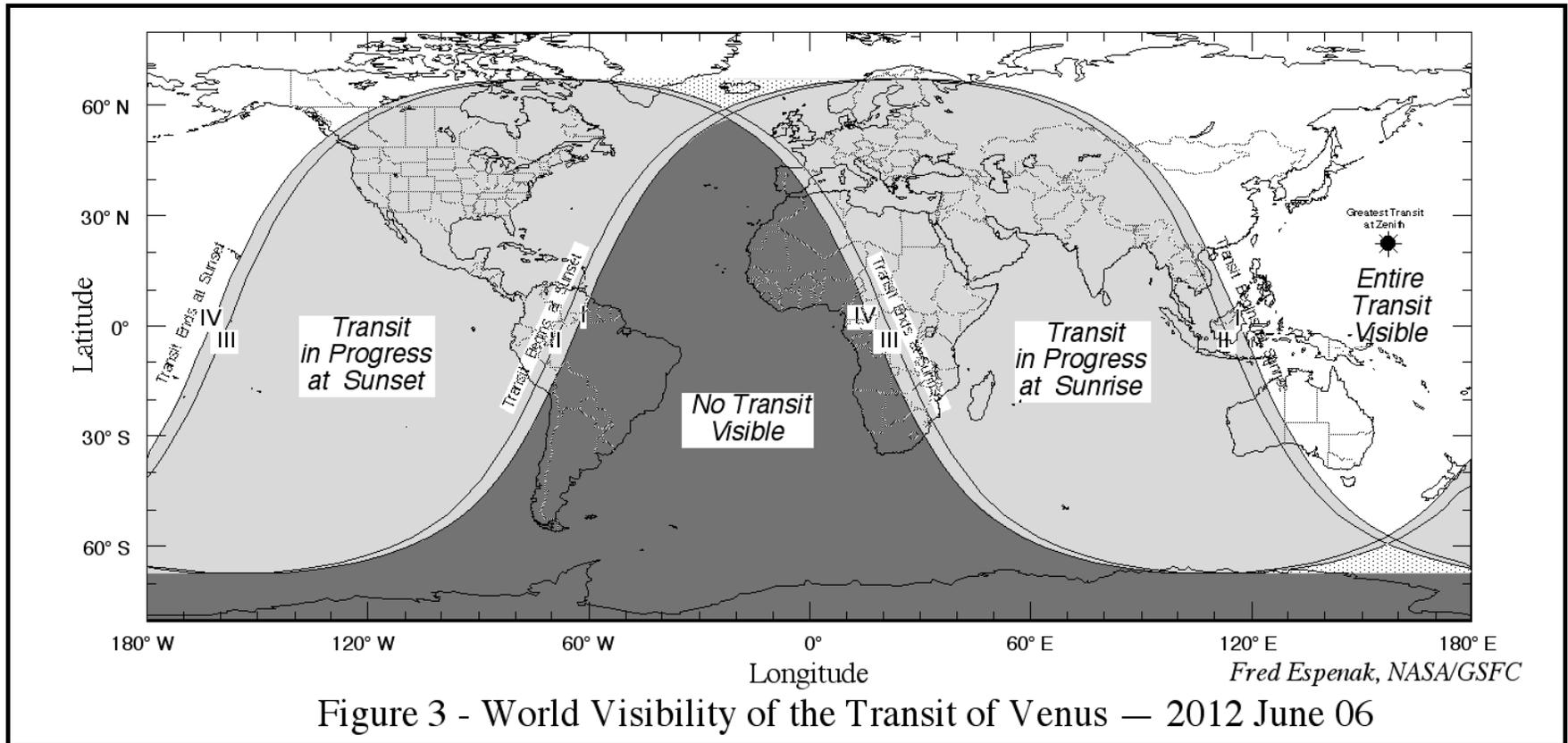
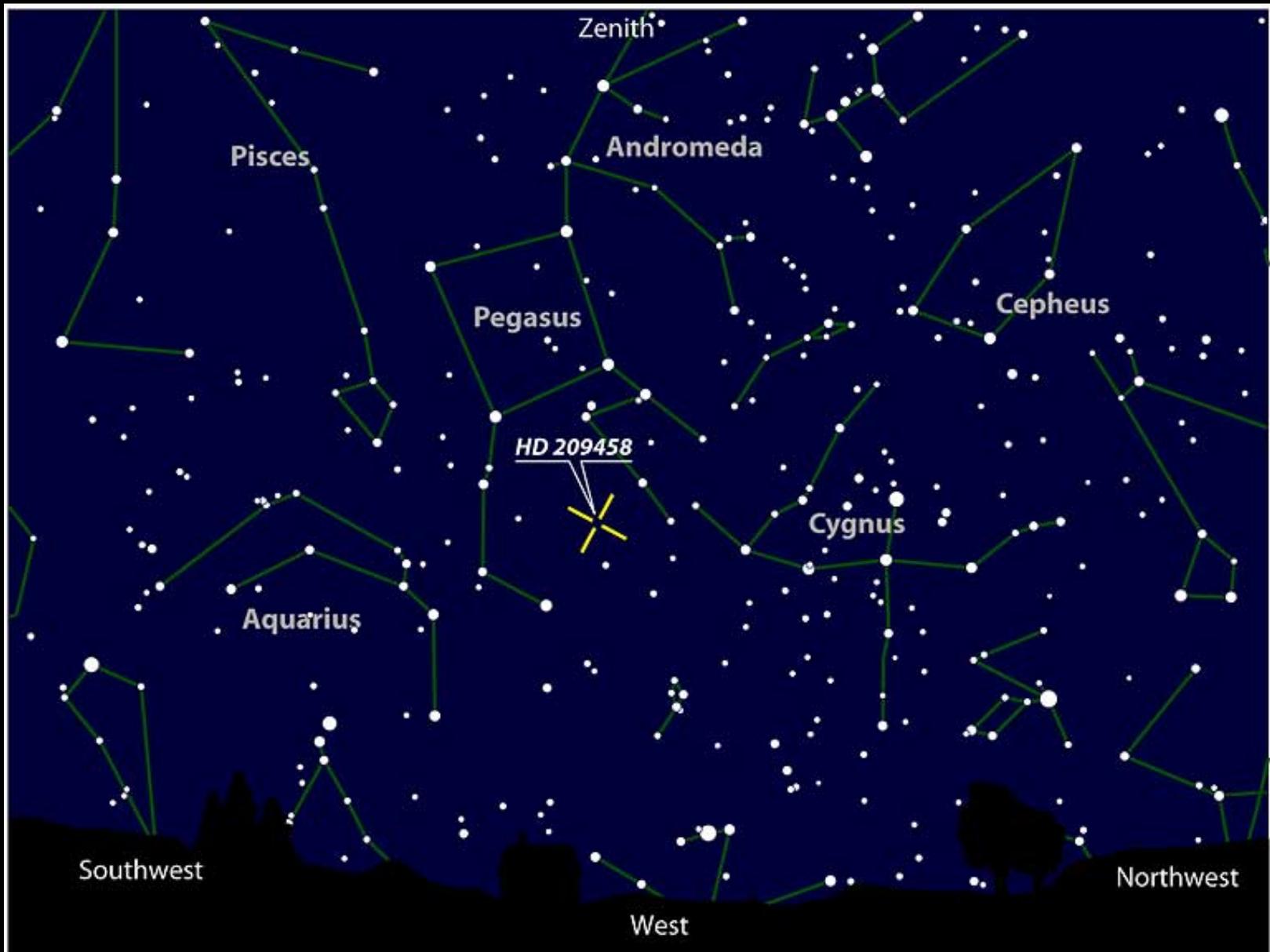


Figure 3 - World Visibility of the Transit of Venus — 2012 June 06

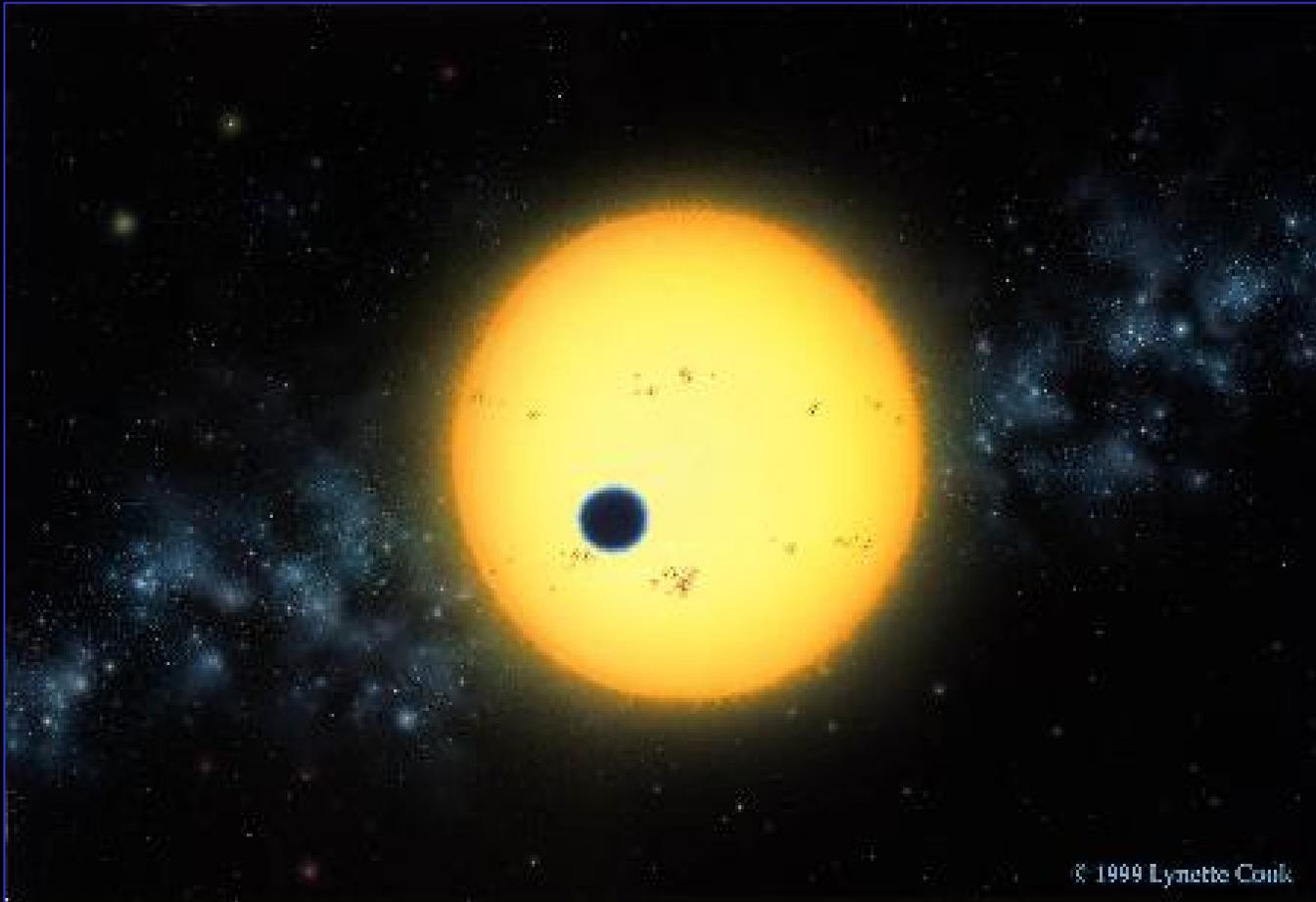
Plan for your summer vacation ... in 2012!



The sky at about 9:00p.m. local time in early December, facing toward the west

Shadow play in *HD 209458*

Transiting exoplanet



artist's conception

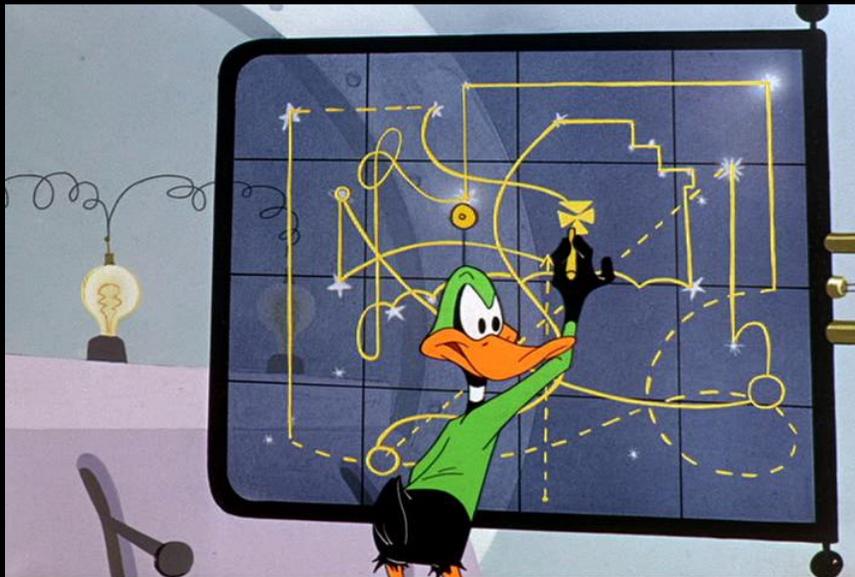


Mercury

Sun

HD 209458

Transiting exoplanet



Position: RA = 22 03 10.8
Dec = +18 53 04
Distance: 47 pc ~ 153 ly
Constellation: Pegasus

Star

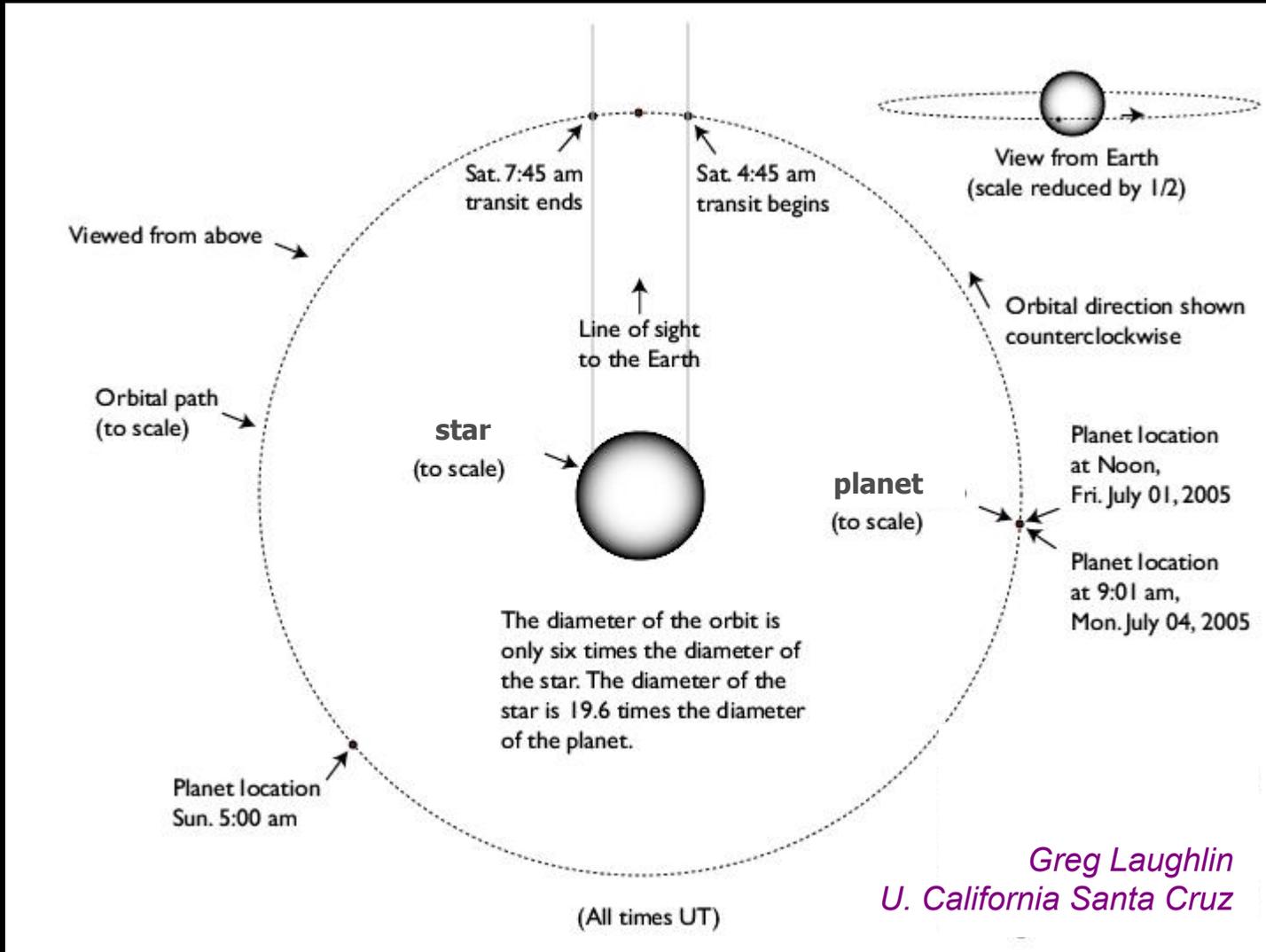
Magnitude (Star): $V=7.64$
Spectra Class: G0 V
Temperature: 6000 K

Planet

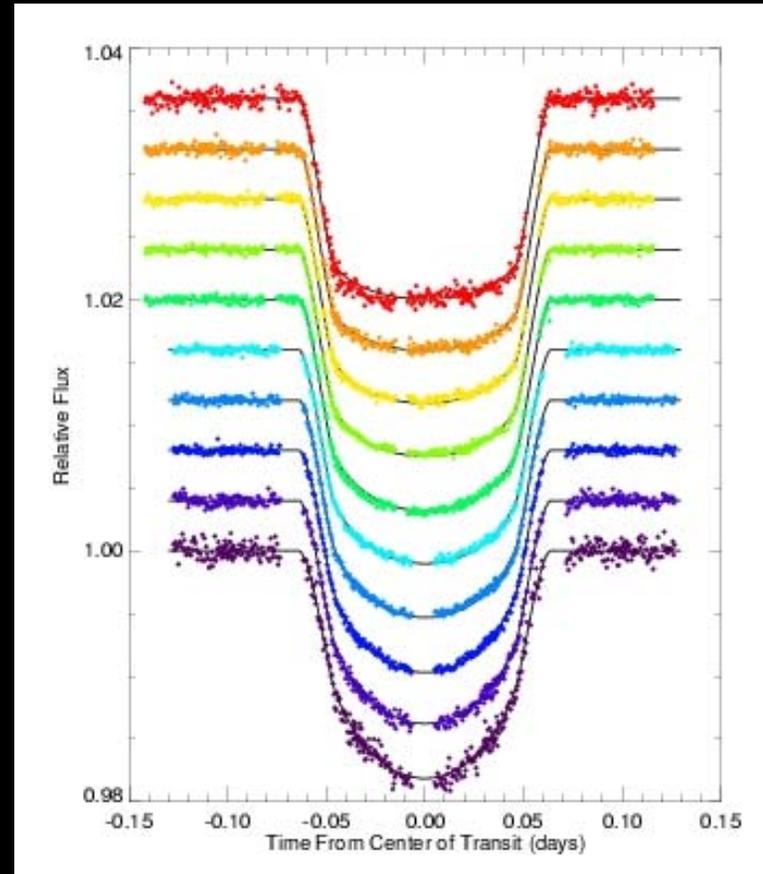
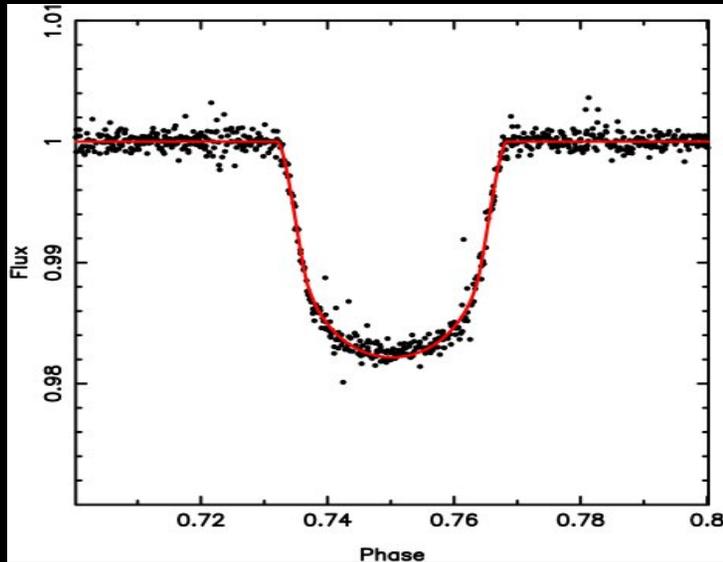
Orbital Period: 3.52 days
Semi-major axis: 0.046 AU
Eccentricity: 0
Mass: $0.68 \times$ Jupiter
Radius: $1.35 \times$ Jupiter

HD 209458

A year in a long weekend!



HD 209458



- ✓ measurement of the transit of the giant planet by MOST
- ✓ measurement of the transit of the giant planet by HST

HD 209458

Knutson et al. 2006

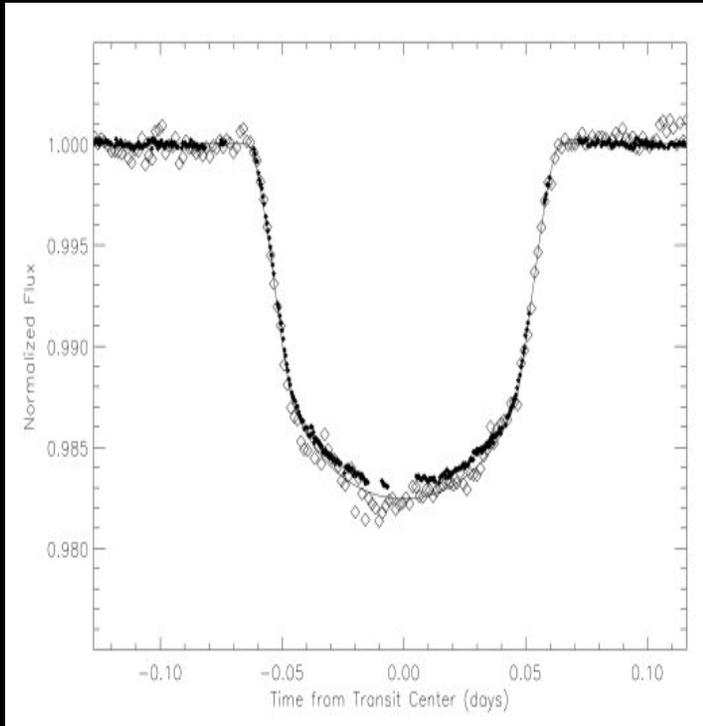


Table 4. Comparison between best-fit values and results from previous works

Study	R_p (R_{Jup})	Inclination ($^\circ$)	M_* (M_\odot)	R_* (R_\odot)
Wittenmyer et al. (2005)	1.35 ± 0.07	86.668	1.09 ± 0.09^a	1.15 ± 0.06^a
Winn et al. (2005)	1.35 ± 0.06	86.55 ± 0.03	1.06 ± 0.13^b	$1.15^{+0.05}_{-0.06}$
This Work	$1.320^{+0.024}_{-0.025}$	$86.929^{+0.009}_{-0.010}$	$1.101^{+0.066}_a$	$1.125^{+0.020}_a$

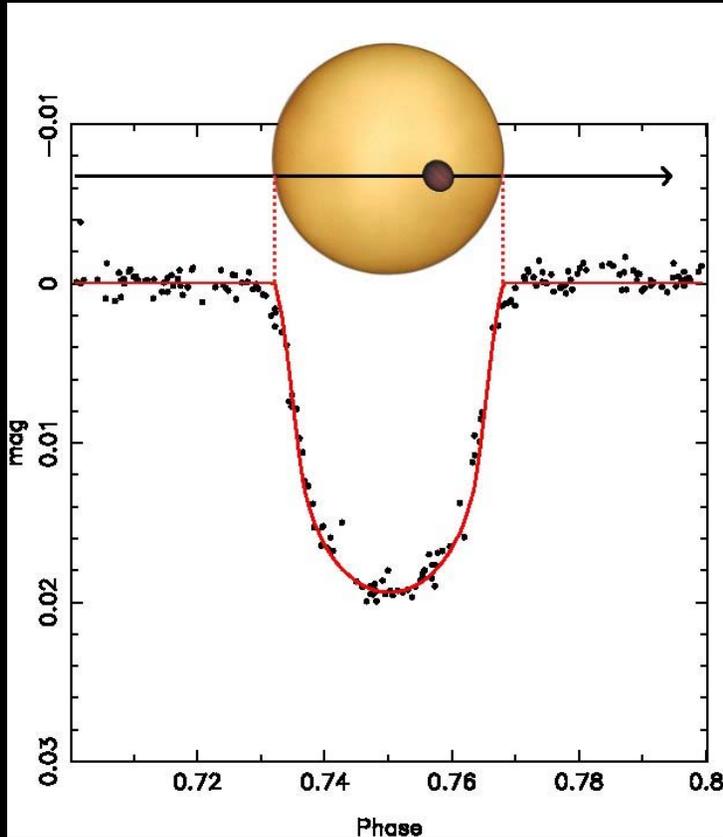
^aUsed stellar mass-radius relation from Cody & Sasselov (2002)

^bAssumed value for the stellar mass from Cody & Sasselov (2002)

- nonlinear limb-darkening
 - Kurucz models
 - specific to MOST bandpass
- stellar radius:
 - $1.121 \pm 0.003 R_{Sun}$
- planetary radius:
 - $1.346 \pm 0.002 R_{Jup}$

✓ MOST transit data leads to slightly larger radius than HST but agrees with independent groundbased measurements

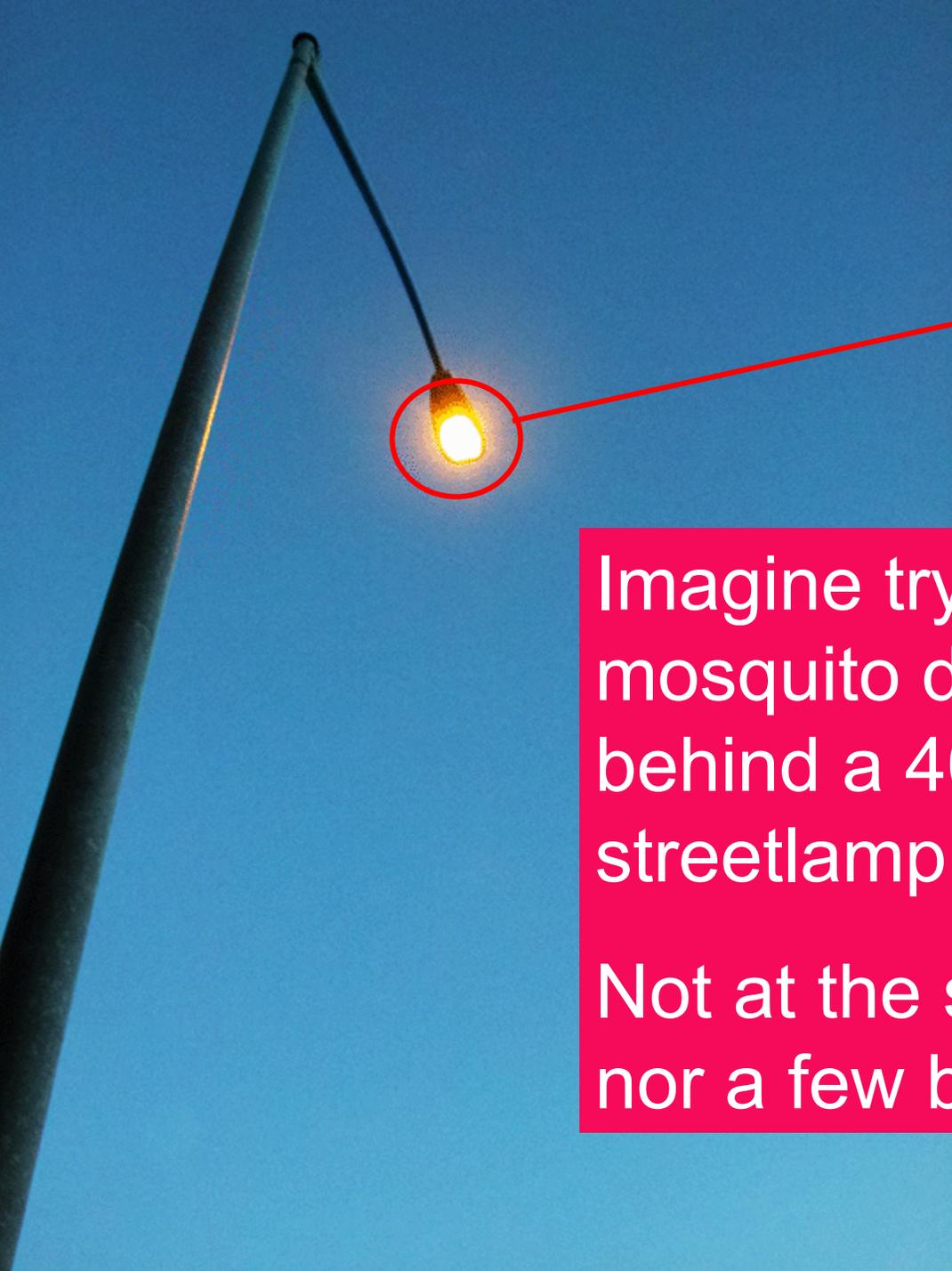
HD 209458



- ✓ measurement of the eclipse of the giant planet by MOST

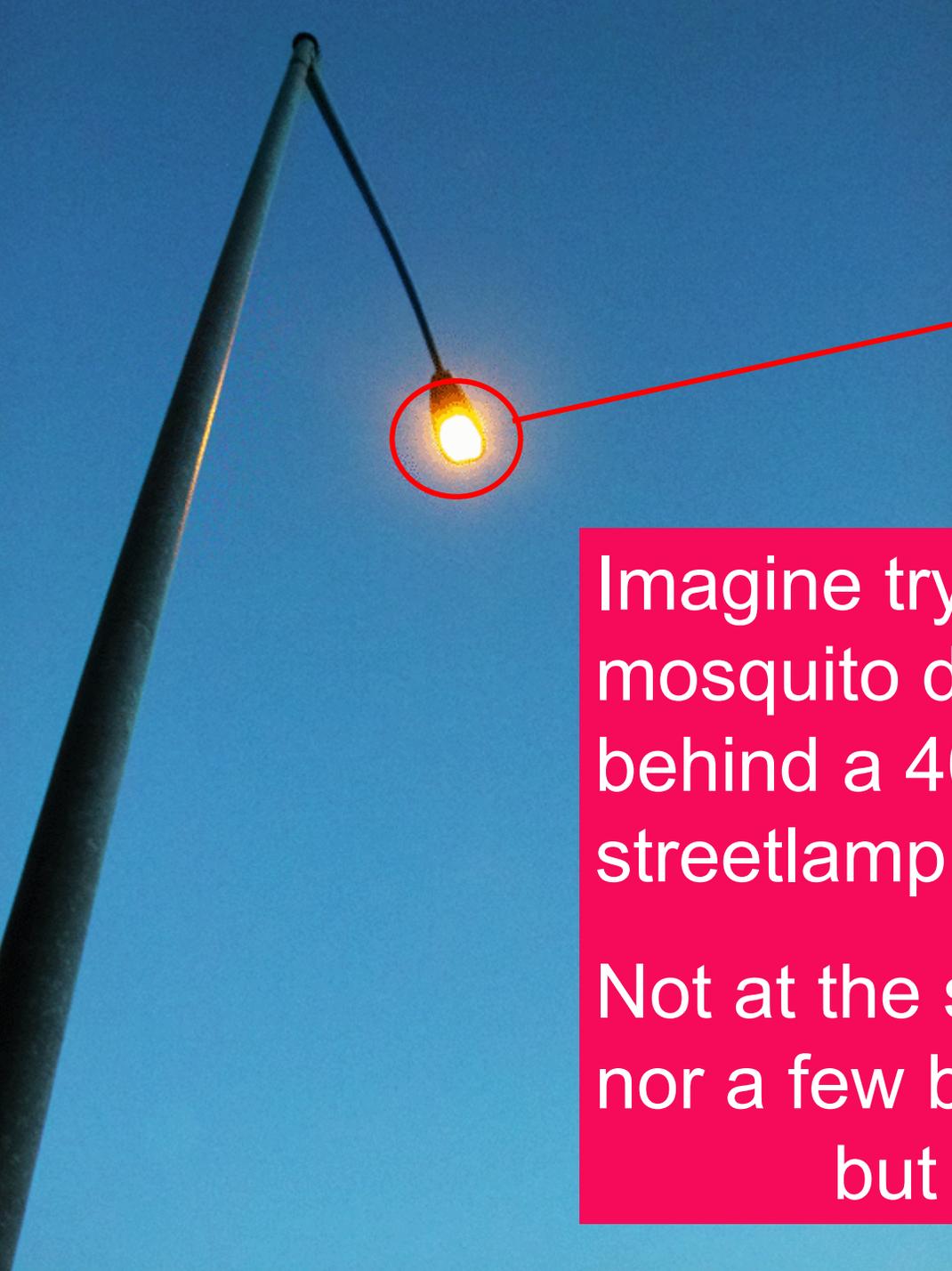


Imagine trying to see a mosquito disappearing behind a 400-Watt streetlamp.



Imagine trying to see a mosquito disappearing behind a 400-Watt streetlamp.

Not at the street corner, nor a few blocks away...



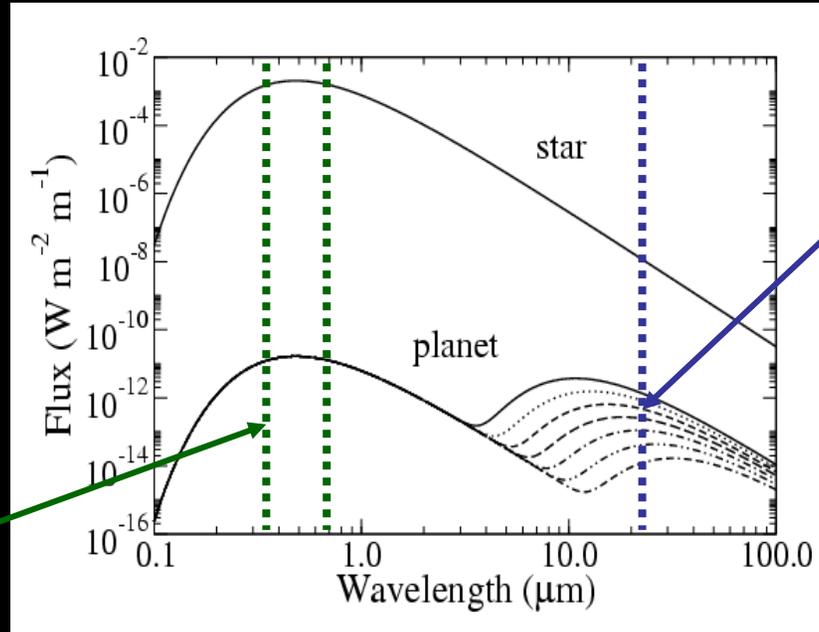
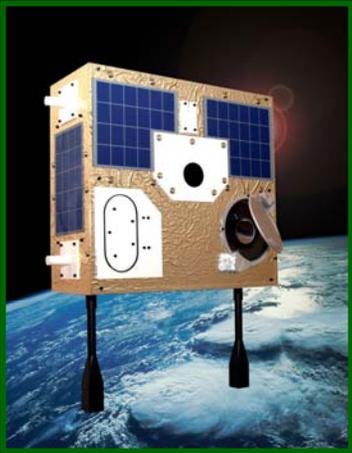
Imagine trying to see a mosquito disappearing behind a 400-Watt streetlamp.

Not at the street corner, nor a few blocks away...

but 1000 km away!

Exoplanetometeorology

**MOST
optical**



**Spitzer
infrared**

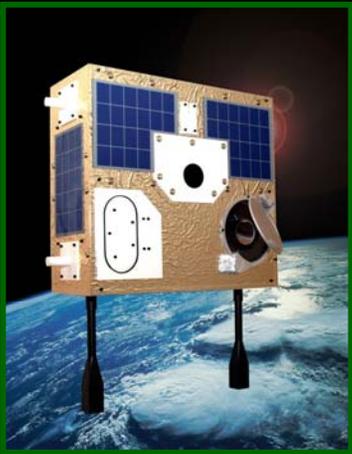
*Deming et al. 2005
Nature 111, 111*

*Rowe et al. 2008
Astrophysical Journal*

- search for transits at other periods \rightarrow *eccentricity, moons?*
- timing of successive transits \rightarrow *Earth-sized planets?*
- measurement of eclipse of giant planet \rightarrow *albedo*

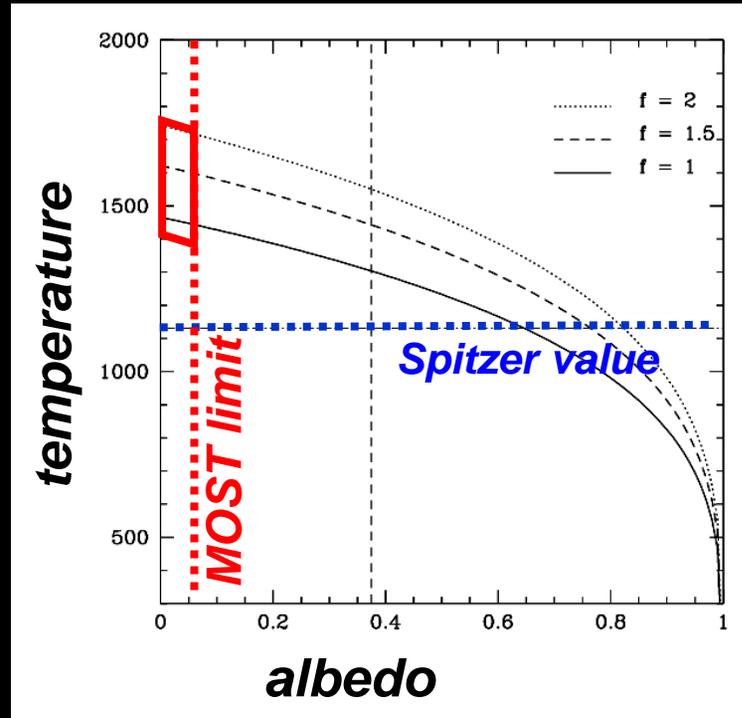
Exoplanetometeorology

MOST
optical



Rowe et al. 2008
Astrophysical Journal

models of planet atmosphere

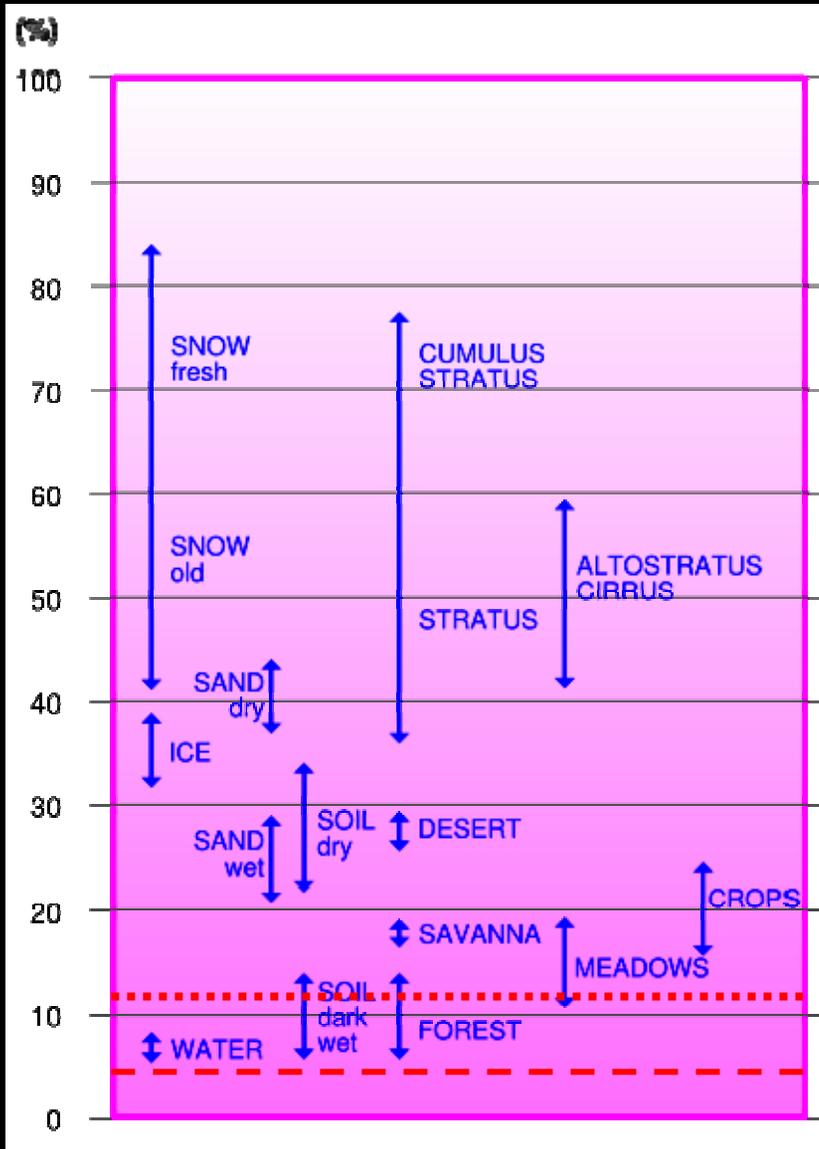


Spitzer
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Exoplanetometeorology



Exoplanetometeorology

Lunar maria		
Lunar highlands		
Mars sky near horizon		
Mars dark regions	neutral light	Martian light
Mars light regions		
Titan		
Jupiter belts		
Jupiter zones		
Io polar		
Io 'red'		
Io 'orange'		
Don Davis planet colour chart		
Io 'yellow'	Voyager based colors	Galileo based colors

HD 209458b

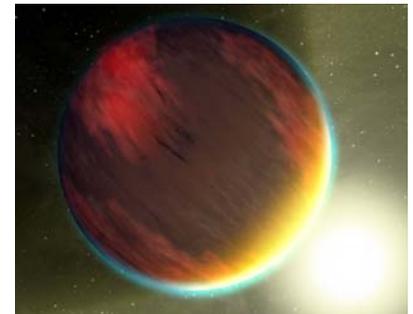


<i>Mercury</i>	<i>Venus</i>	<i>Earth</i>	<i>Moon</i>	<i>Mars</i>
<i>0.119</i>	<i>0.75</i>	<i>0.29</i>	<i>0.123</i>	<i>0.16</i>
<i>Jupiter</i>	<i>Saturn</i>	<i>Uranus</i>	<i>Neptune</i>	
<i>0.343</i>	<i>0.342</i>	<i>0.290</i>	<i>0.31</i>	

Exoplanetometeorology



MOST data are helping us understand the weather and clouds on a planet you can't even see around a star 160 light years away!?!



Exoplanetometeorology



MOST TV

I : Ammonia Clouds

~~II : Water Clouds~~

III : Clear

IV : Alkali Metal ✓

~~V : Silicate Clouds~~

Predicted Albedos:

IV : 0.03 ✓

~~V : 0.50~~

Conception of a Sudarsky Class IV planet generated using Celestia Software

***Sudarsky
Planet
Classes***

Gliese 581c: A superEarth

EARTH



5000 km
(3107 mi)

GLIESE 581 C

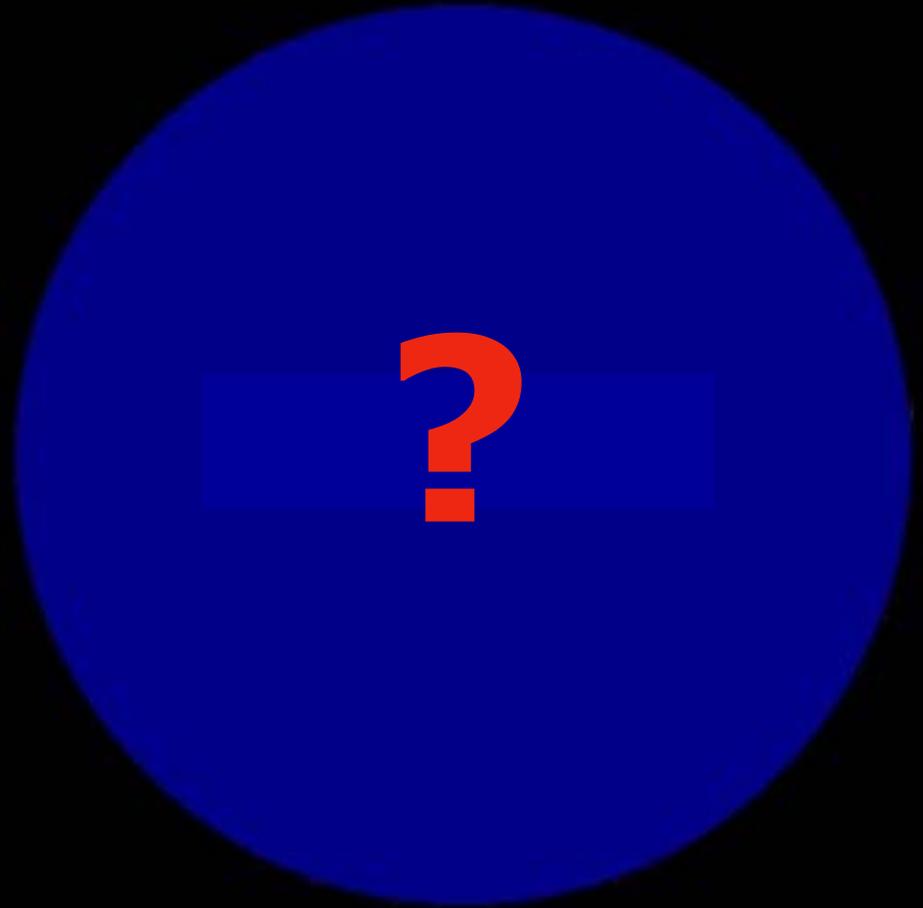


Gliese 581c: A superEarth

EARTH

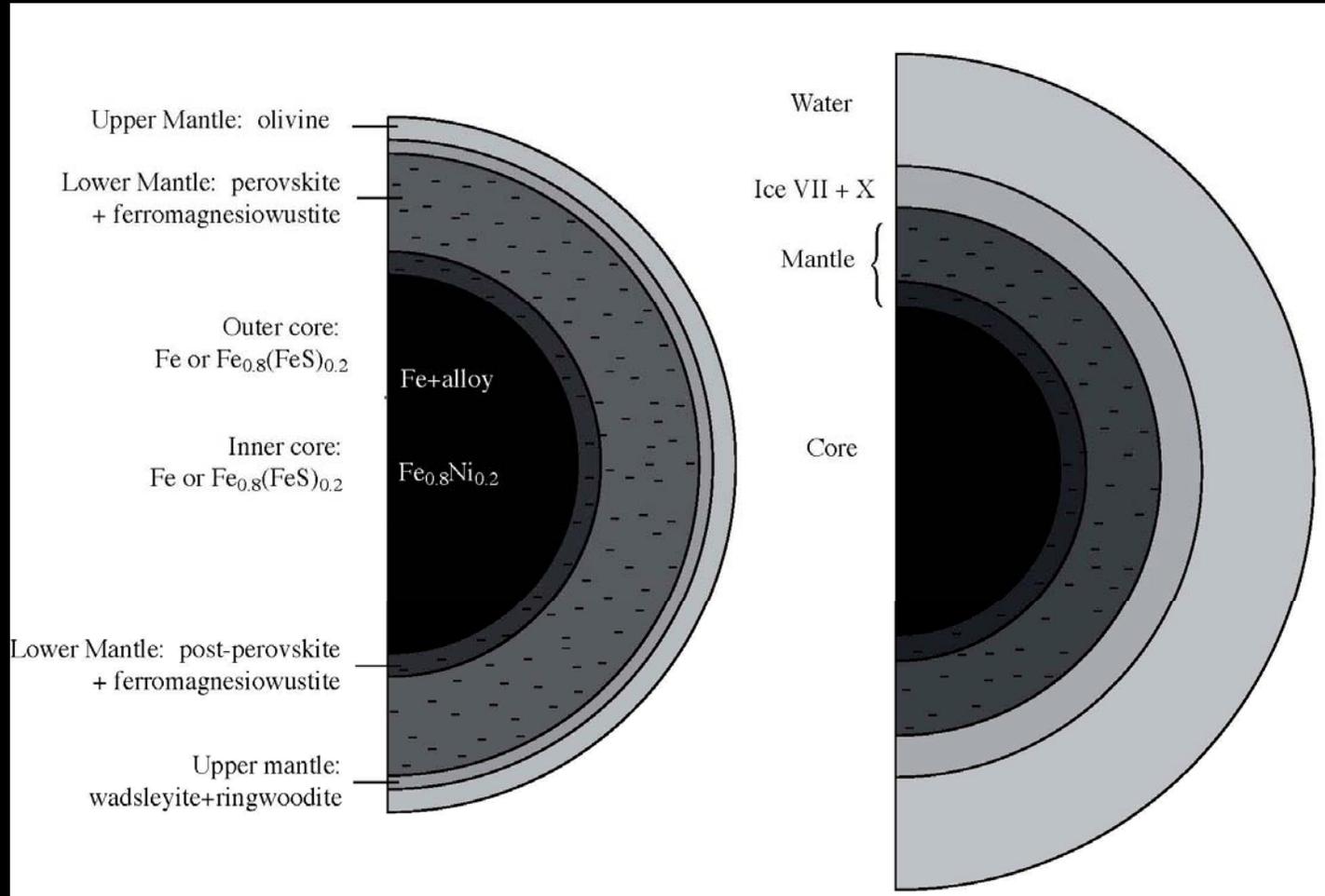


5000 km
(3107 mi)



Gliese 581c: A superEarth

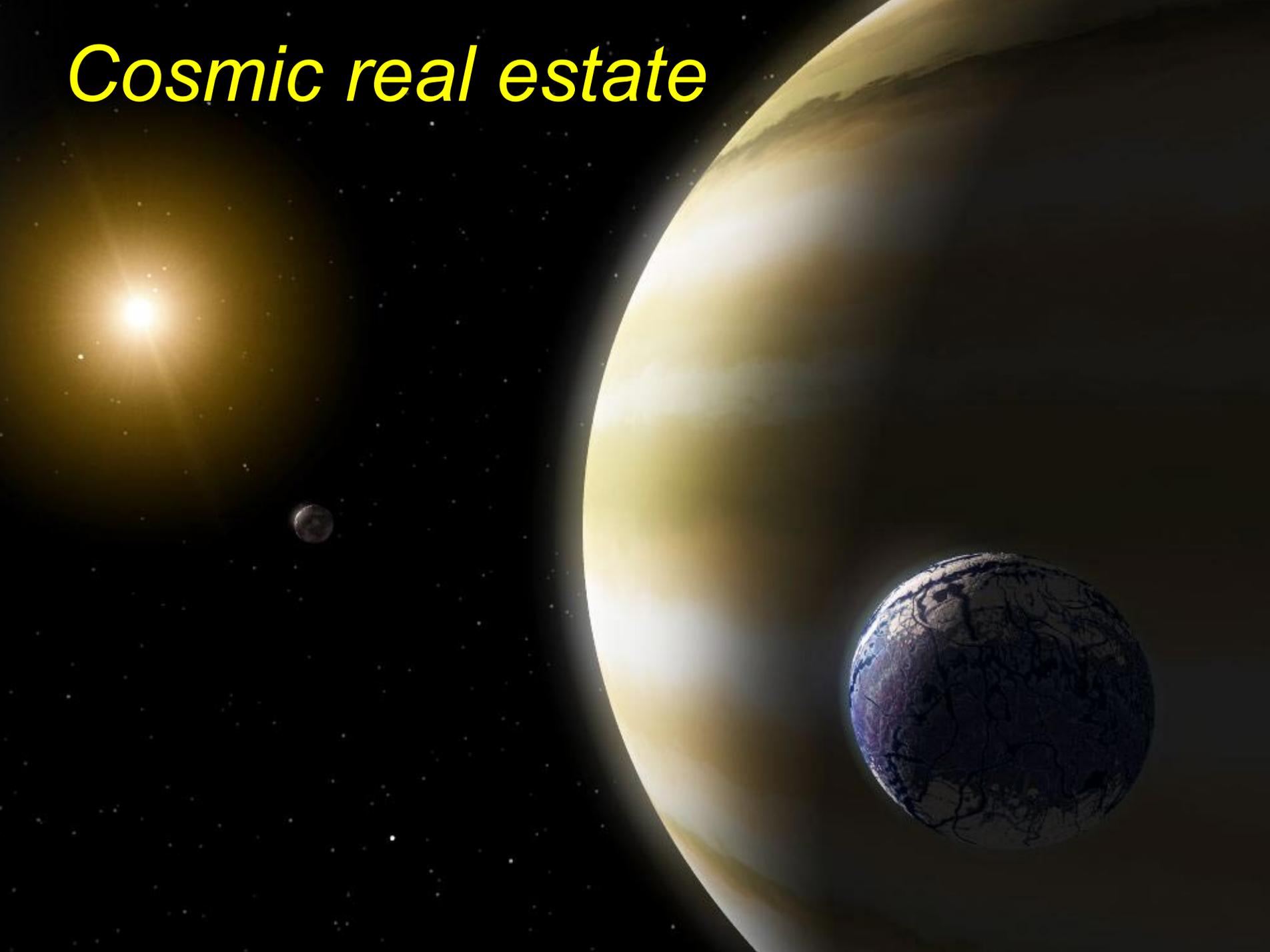
Interior models



Earth-like

Ocean Planet

Cosmic real estate



*I've become a
real estate agent
to science fiction writers*

Century
21,000
Realty Plus



Searching for Terra Nova

- *The MOST space telescope is the first instrument which can detect alien Earths*
- *It is the pioneer for future space missions:*
 - *COROT (France; launched Dec 2006)*
 - *Kepler (USA; launch 2009)*

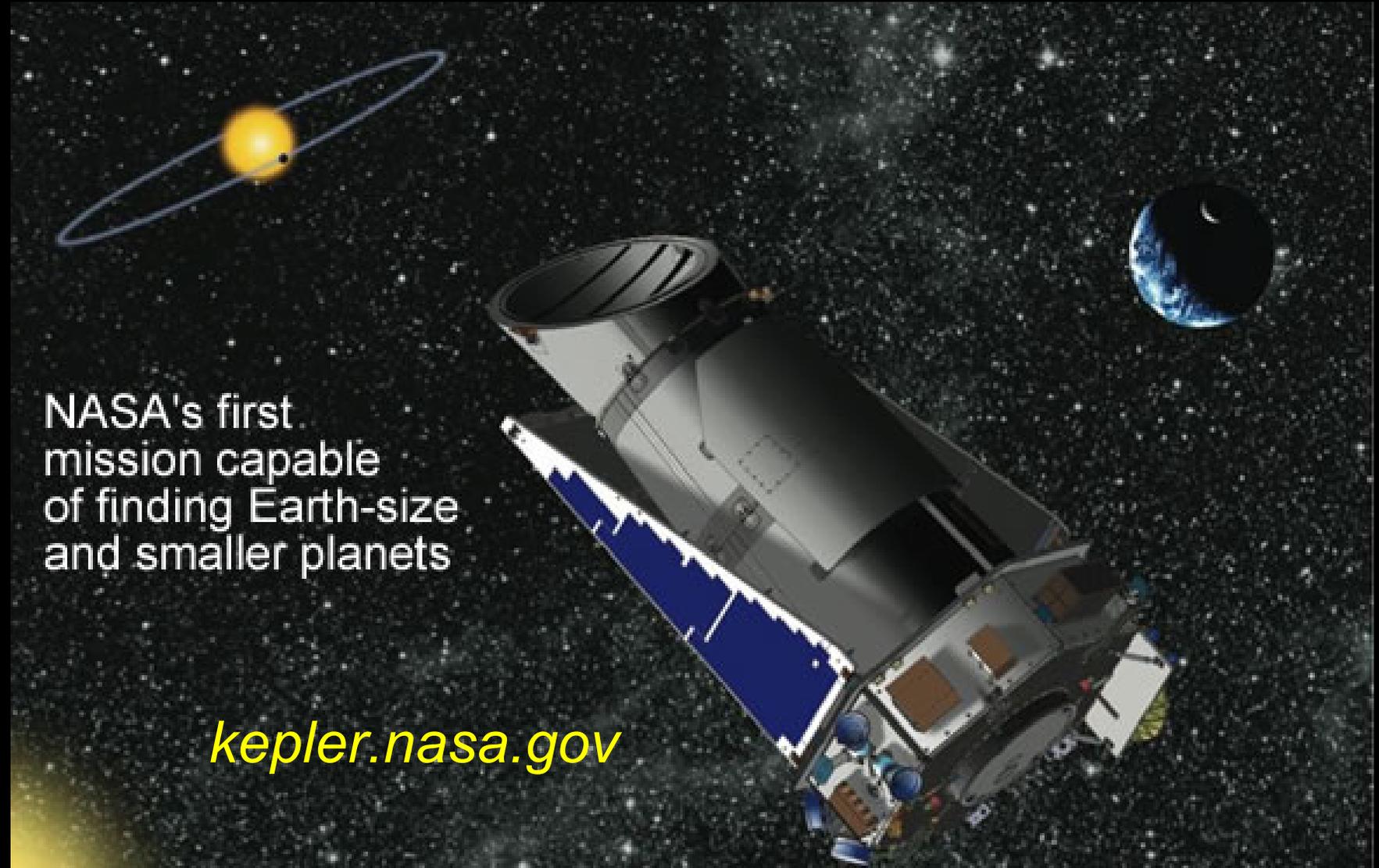


www.astro.ubc.ca/MOST

The search is on...

Searching for Terra Nova

The Kepler Mission

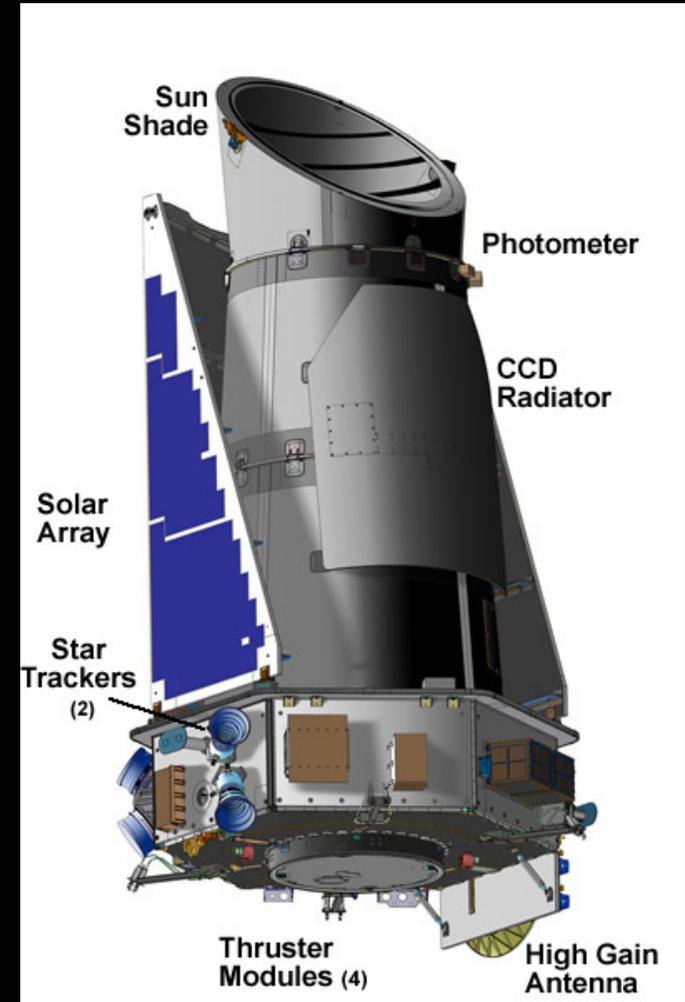
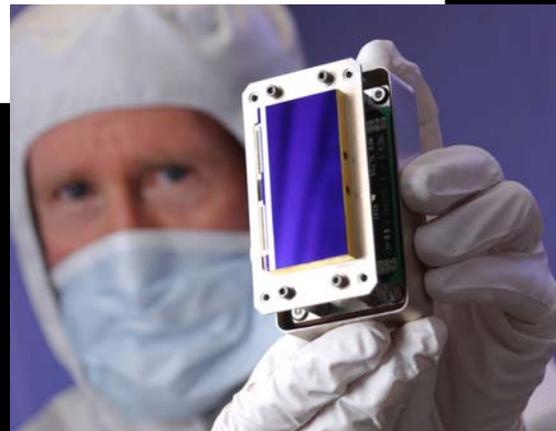
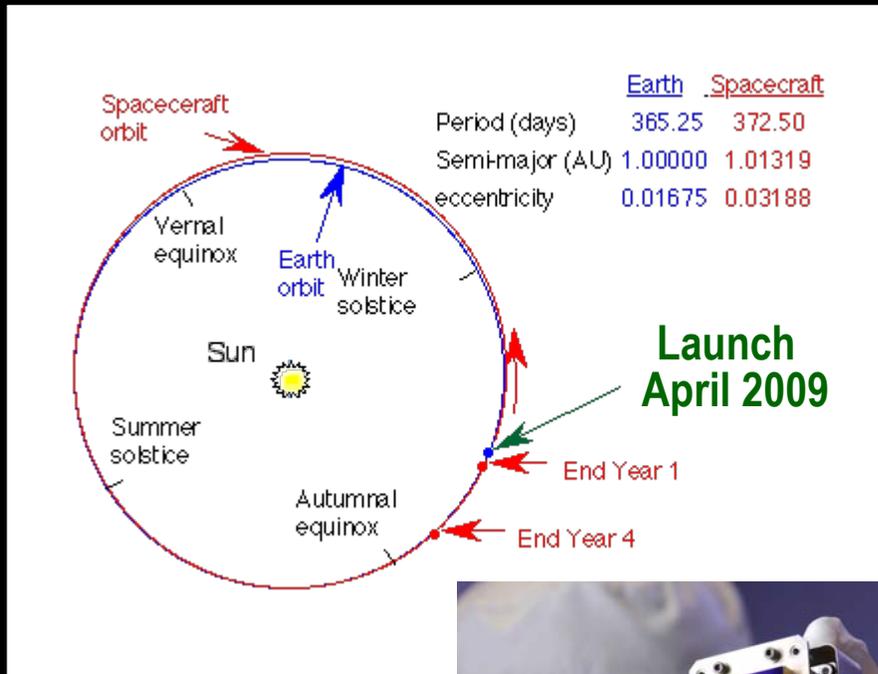


NASA's first mission capable of finding Earth-size and smaller planets

kepler.nasa.gov

Searching for Terra Nova

The Kepler Mission



Searching for Terra Nova

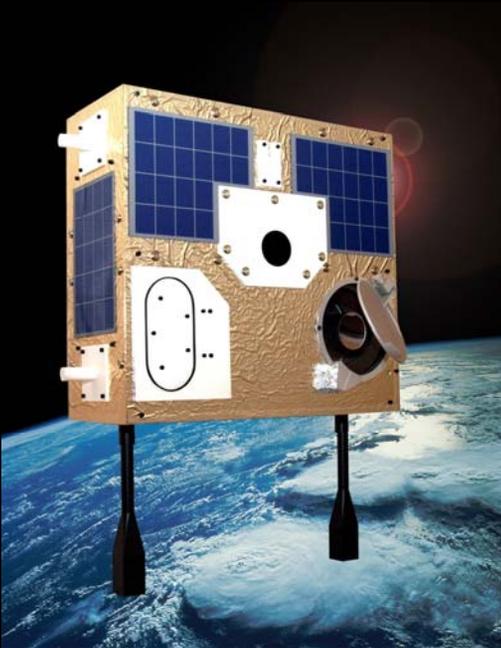
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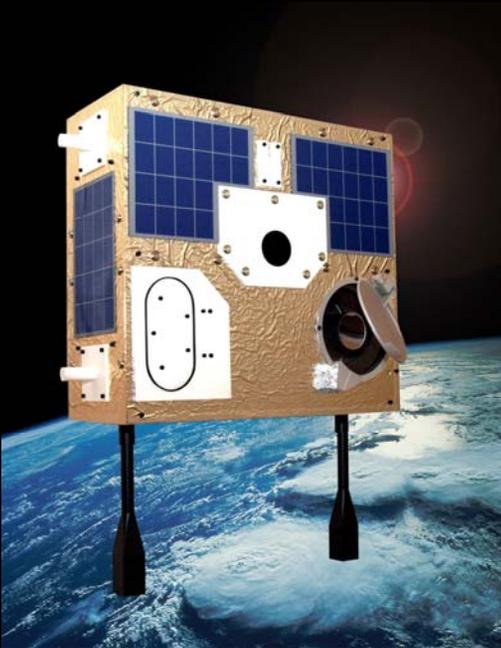
Searching for Terra Nova



“I see the Earth.
It is so beautiful.”

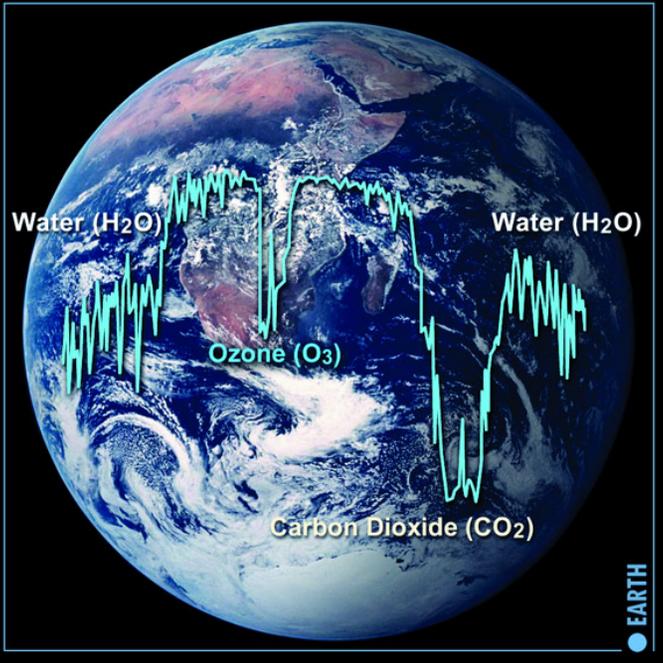
Yuri Gagarin (1961)

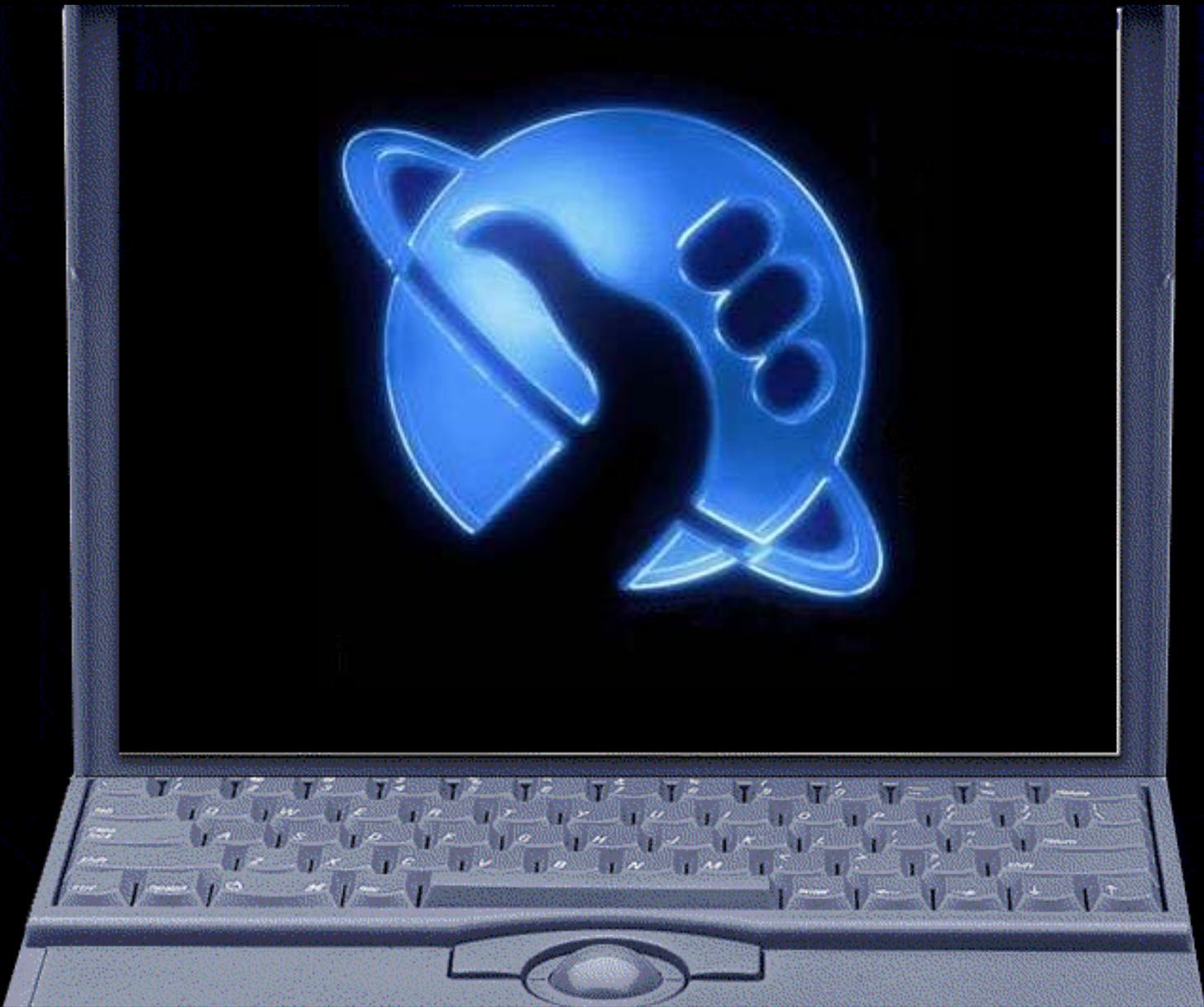
Searching for Terra Nova



“I see another Earth.
It is so beautiful.”

*Jaymie Matthews
and the MOST Team (200?)*





The Hitchhiker's Guide to the Galaxy

Earth: Harmless



The Hitchhiker's Guide to the Galaxy – 1st Edition

Earth: Mostly Harmless



The Hitchhiker's Guide to the Galaxy – 2nd Edition

exoEarth 1:
Wow!



The MOST Guide to the Galaxy – Future Edition?



Did I leave
time for any
questions?

www.astro.ubc.ca/MOST



Agence spatiale
canadienne

Canadian Space
Agency



MOST

Microvariability & Oscillation of Stars

Microvariabilité & Oscillations Stellaires

AMSAT • UTIAS • Dynacon

UBC • CRES Tech • Ontario

