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JAHOU

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1 au : a step toward the universe
ideas from JAHOU

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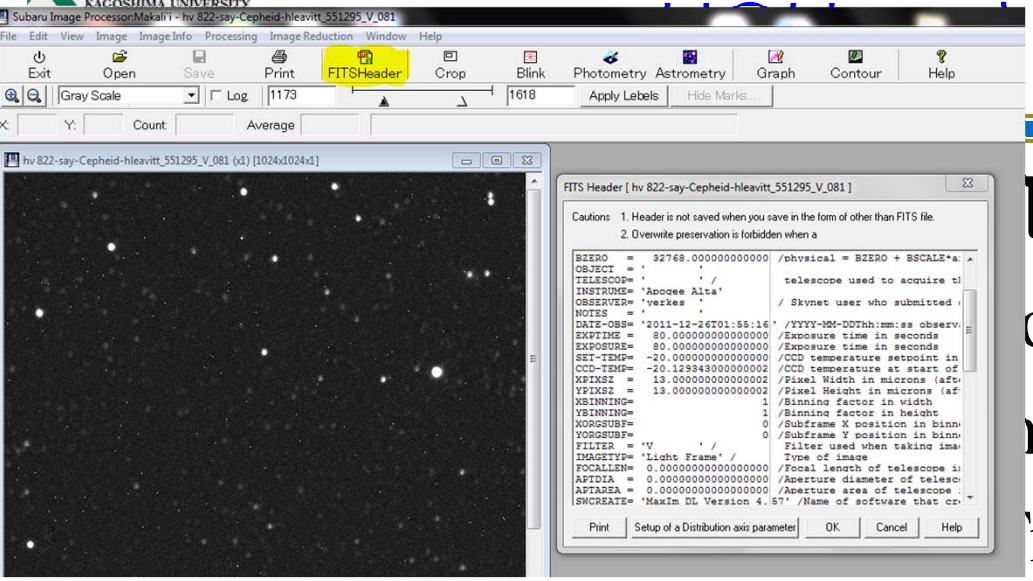
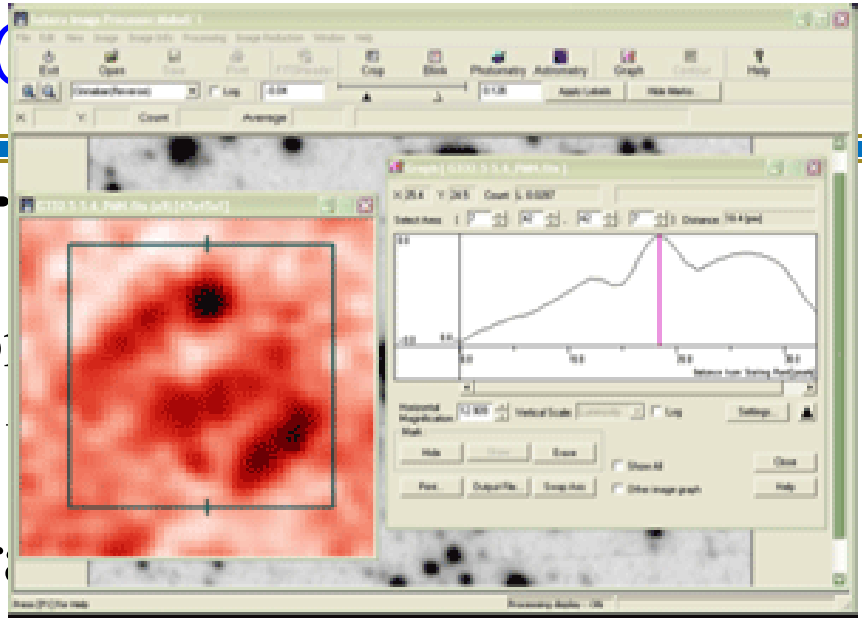




- **Measure images!**
  - FITS image + image processing software
  - Makalii, Salsa-J
  - inquiry based, active learning
  - citizen's science

topic told at GHOU2013

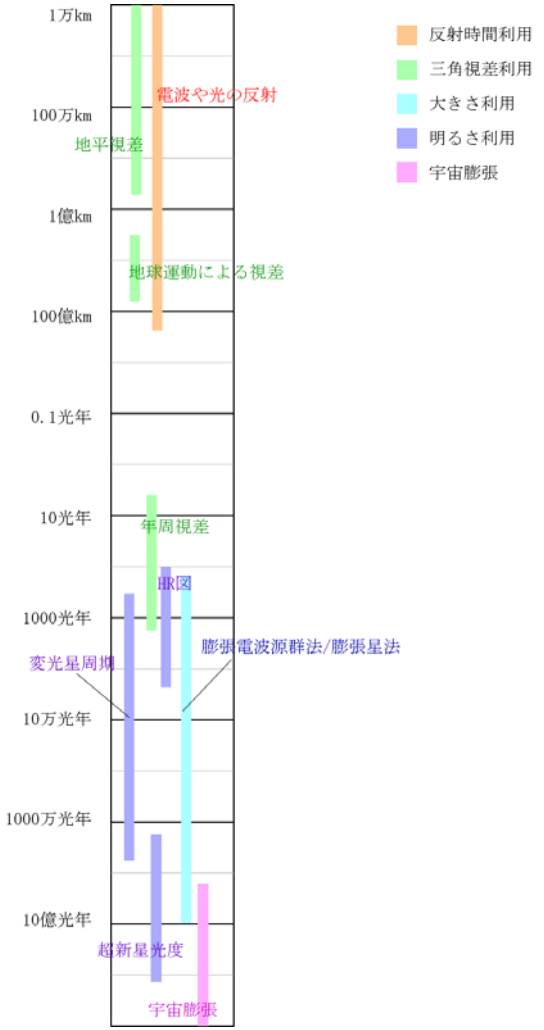
- An old ideas but still valuable.

History to measure 1 au

- 1716: Halley proposes Venus transit obs.
- 1761: 1st coordinated astron. obs. over the world
- 1769: got the value as 1.53×10^8 km
  - 150 yrs before IAU established

Distance to celestial objects

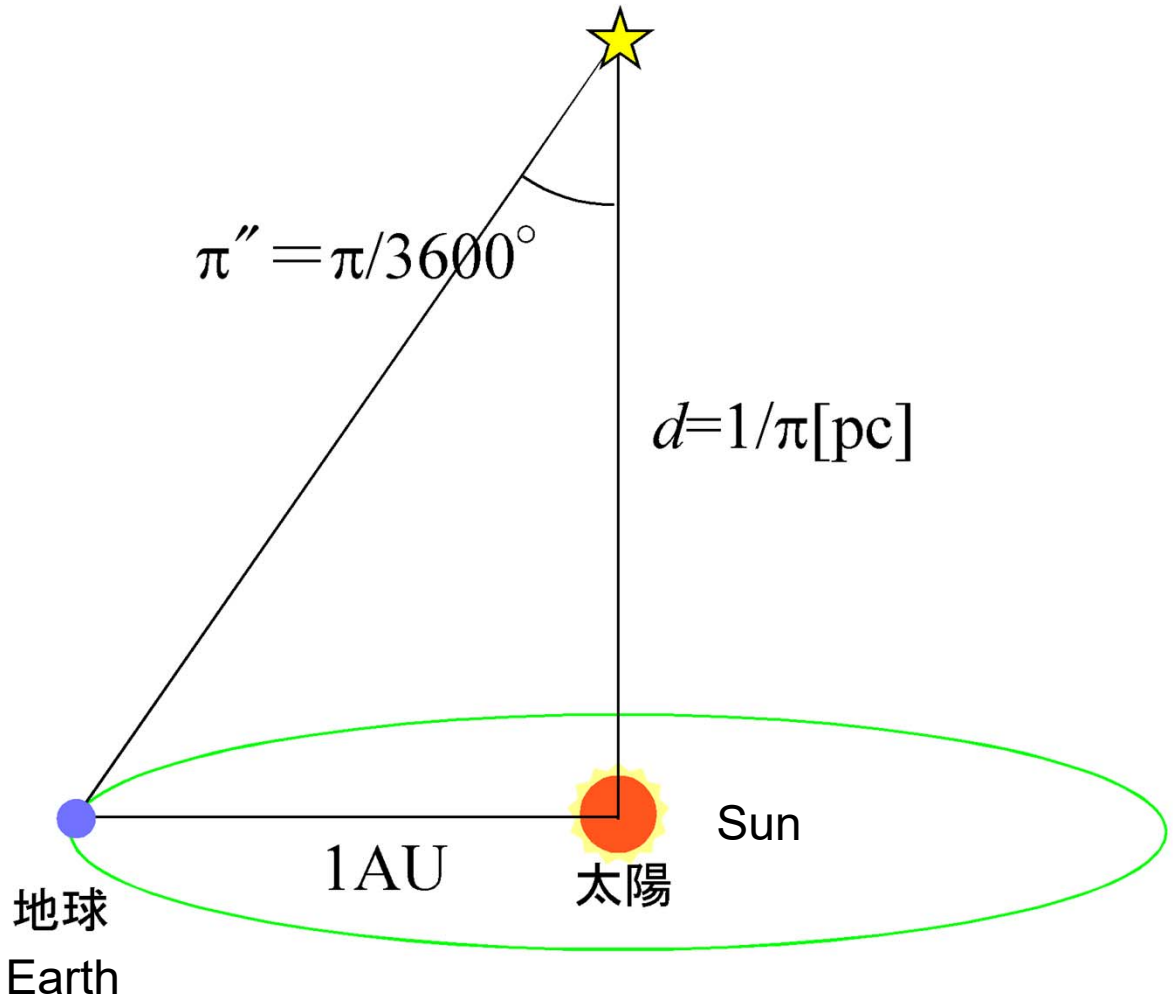
- **Distance estimation**
  - The biggest issue in astronomy
- **The distance scale ladder**
  - annual parallax
  - eclipsing binary
  - Cepheid, Mira
  - HR diagram: photometric distance
  - Tully-Fisher/Faber-Jackson relation
  - Ia SN
  - etc.



Distance estimation

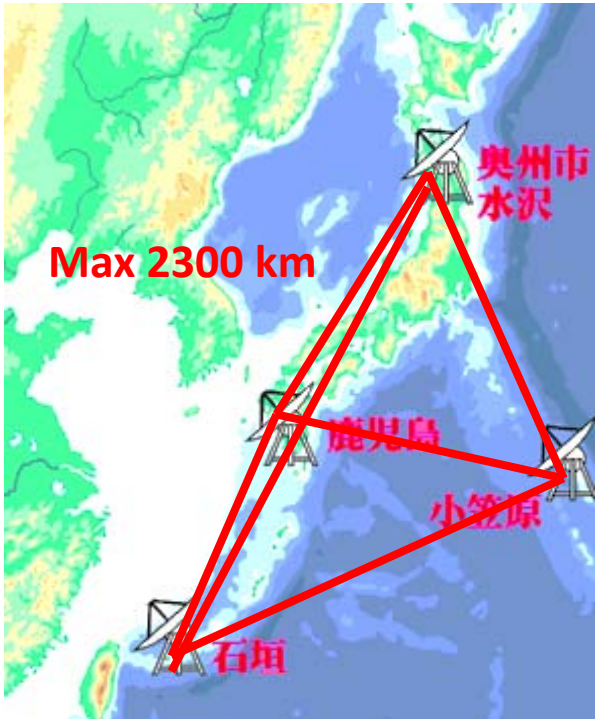
- **To give an actual physical parameters**
  - mass, size, energy
    - size ~ d
    - mass ~ d^2, d^3
    - energy ~ d^2, d^3
- **Annual parallax is the starting point.**

Annual parallax



In a cutting-edge astronomy

- **Direct measurements of annual parallax**
- **VERA**
  - VLBI exploration of Radio Astrometry
- **Hipparcos, Gaia**



Importance to get 1 AU

- **How to connect between km and AU**
  - not only the traditional/current way
  - many methods
  - use the actual data
- **It is a HOU way!**

ideas

A) Venus transit

- simpler way than Halley's

B) Spin of the Sun

- a part of JAHOU spectrum curricula

C) modulation of periodic phenomena

- Inverse use of Rømer's light speed measurement

D) Annual aberration

Idea A)

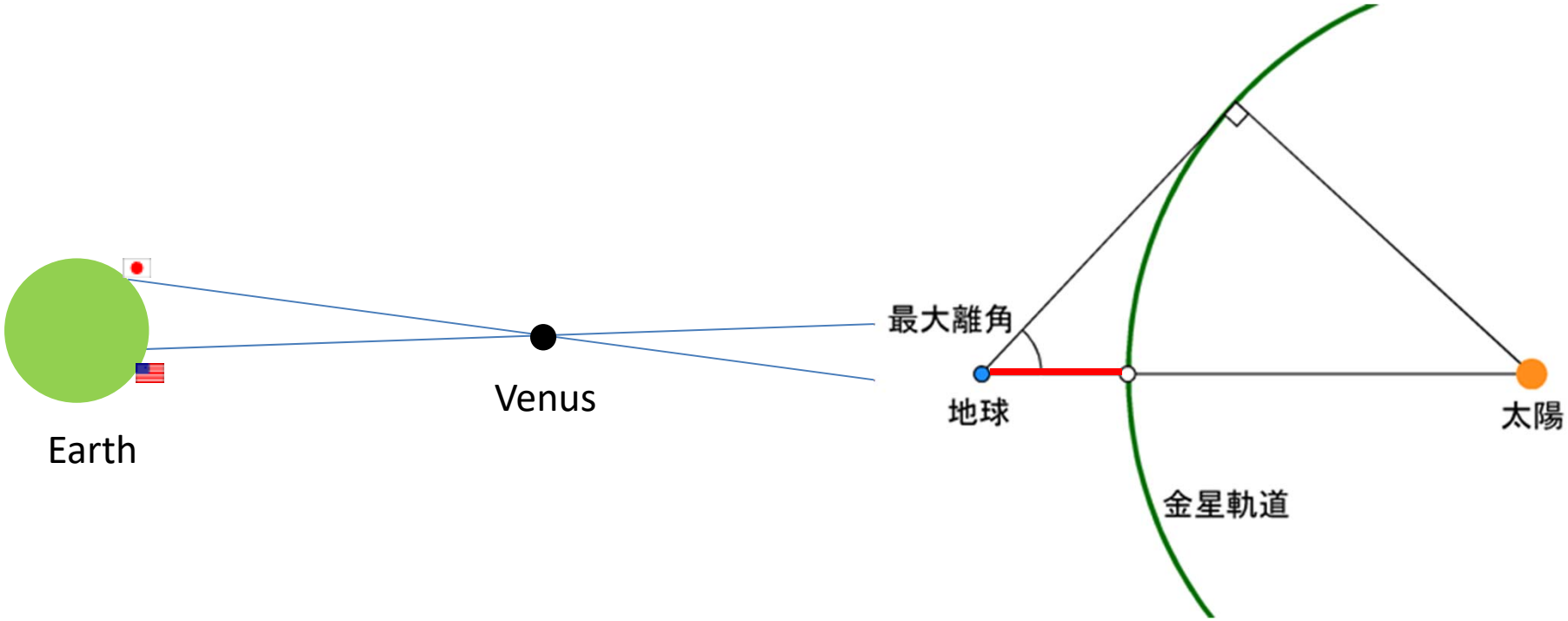
Venus transit for AU

The Venus transit!

- **Parallax of Venus in front of the Sun**
- **Estimate the distance to Venus**
  - It should be about 15” for 3000 km baseline.
  - Across a continent or an ocean

Simultaneous observations

- **Similar observations as a solar eclipse**
- **More direct procedure than Halley's**



A “standard” procedure

- **The distance to Venus**
  1. Measure the parallax using FITS images
  2. Measure the baseline length at that time
- **The ratio of orbital radii**
  3. Measure the maximum separation of Venus
  4. Measure the ratio of Earth and Venus orbit radii

Idea B)

Spin of the Sun for AU

A part of JAHOU spectrum

- **Spin rotation velocity from spectra**
  1. Solar spectra in E-W edges
  2. Rotation velocity using Doppler effect
- **Rotation period**
  3. Rotation period from sun spot obs.
- **Sun Radius**
  4. Round trip length by $l=T_{\mathrm{rot}}\ v_{\mathrm{rot}}$
  5. Sun radius from $R=l/(2\pi)$
- **Apparent size distance**
  6. Apparent Sun radius $\theta=0.5\mathrm{deg}$
  7. 1 au from $d=R/\theta$

Idea C)

Rømer's method

Rømer's method for c

- Lite speed by light travel across 1AU
- Using timing clock by Jupiter satellites
- We can measure c in these days.
- Use this method inverse direction

Period measurements

- **Period measurement using Makalii**
  1. Eclipse timing and period of a Jupiter's satellite
  2. measure them in different seasons
- **Light traveling time difference**
  3. Derived the modulation by Earth motion
  4. Measure the light traveling time difference T_{travel}
- **Light traveling distance difference**
  5. Difference of light traveling distance $l = T_{\mathrm{travel}}\, c$
  6. Locations of Earth and Jupiter on SSSim
  7. Distance l in au; about 2au for a half year

extension

- **A Periodic variable : another candidate**
- **The best target**
  - short period variables; $T \sim$ several days
  - near the ecliptic plane

Idea D)
Abberation measurement

aberration

- **Measure the annual aberration**
  1. Aberration angle θ
     - Problem: How to do it?
- **Orbital speed of Earth**
  2. Orbital speed is estimated by $v=c\ \theta$
     - $\theta\ v/c = 10^{-4}$ rad=20”
- **Orbit length**
  3. Orbit length $l=T_{yr}\ v$, where T_{yr}=1 year in sec.
- **Radius of Earth orbit**
  4. Orbit radius from $R=l/(2\pi)$
- **Problem: How to measure it?**

New ideas!

- Please give new ideas!
- Collect good ideas!
- A new chapter in the GHOU textbook!