Team project #1

Team projects

3 teams, 4 to 5 students per team.
Each team is given a project in the form : how would you design, build, test and operate a telescope/instrument to solve an astrophysical problem

Schedule:

TODAY (Feb 1): Project assignments given and discussed

NEXT 10 DAYS (Feb 1 → Feb 10): work on project, ask questions to Guyon, Hinz & Burge
guyon@naoj.org, phinz@as.arizona.edu, JBurge@optics.arizona.edu

IN ~5 DAYS : email us where you are at (brief email OK)
This will help us make sure you're on the right track. As questions if you have some. If possible, tell us what is hard about the project, what you don't understand.

IN 10 DAYS (Feb 10): present your project to the class, discuss it with the class
20mn per team. Aim for ~10 slides max (+ backup slides OK). This will be very interactive. Other teams will ask questions / comment.

IN 15 DAYS (Feb 15): email written report on project (this can be slides or written document)
After discussion, update your slides, answer questions & comments. Send us your final report.

Team projects - expectations

Think, learn something, have fun, work together

<u>Some advice:</u>

- **work together**: work should be interactive between team members, distributed among team members. Schedule time to meet and talk about the project.

- **keep it simple – do not focus on details**: no need for detailed optical design. focus on big choices, strategy. Identify what you think is difficult, easy, how you think you would solve or analyze problems. Present what you think the system should look like (eg: wide field telescope, 8m, with a refractive corrector and a ~Gpix camera with 0.2” pixels), how you would use it to solve the problem.

- **look around at what might already exist**: if you find that a telescope/system already does this pretty well, try to complement it: do better or different. Build a project that makes sense even if the existing project goes along.

- **be honest**: explain what you understand and what you don't. The discussion session is a good time to ask questions like: “we didn't know if we need xxxx” or ”We don't understand why xxx”
Note: An oral interactive discussion is very unforgiving – you can't hide what you don't know !

- **present as if you are trying to get me to give you money to do a detailed study**. Can I trust you to make the right design choices ? Do you understand the problem and challenges ?

Team projects - expectations

Think, learn something, have fun, work together

<u>Some advice:</u>

- **think through all steps**: design, fabrication, test, operation
  - Do you expect testing to be challenging ? how do you operate the system ?
  - any information on level of effort (years required to build and test, cost, number of people required) is valuable (but not required !)

- **don't be too nice to other teams, ask hard questions (the ones you would not want other teams to ask you)**

    If you suspect something to be wrong, say it. If you're right, the other team will learn something, if not, you will learn something.

- **think broad**

    Is a conventional telescope optimal for this problem ?
    Should several small telescopes work better ?
    Space or ground ?
    What wavelength ? is optical better, or IR ?
    by the way... once we build this, it could also measure xxxxx ….

Team projects – Roles within team

Program manager (PM)

- Call the meetings. Make sure everybody has well-defined tasks and that they work towards the common goal. He makes sure that things get done.

Chief Scientist (CS)

- Relate science requirements to technical requirements. He is the real driver behind the project

Chief System Engineer (CSE)

- Work towards technical requirements, define system level tradeoffs, report jointly to PM, CS

Chief Optical Engineer (COE)

- Provide preliminary optical designs and optical performance analysis, report to CSE

Team projects – Steps

1. Quantify the physical effects that of interest. Relate them to specific signals that can be observed

2. Choose several ways of getting information from the signals. Identify fundamental limits.

3. Choose a single architecture that seems practical.

4. Define all of the performance requirements that must be met. Relate these to the science.

5. Define specific trade studies that are needed to make decisions. Define these decisions and the information that needs to be obtained to make them.

6. Perform preliminary design and analysis as necessary to make the big decisions.

7. Follow the complete chain: physics in space - atmosphere - telescope optics - instrument optics - detector - data bits - processing.
Understand and quantify how signal flows from space to data. Understand and quantify how and where uncertainties come in: random noise and systematics.

8. Provide preliminary plan for processing the data and making decisions in the presence of noise and bias.

9. Perform preliminary definition of requirements for all of the important subsystems. How do these compare to existing systems?

10. Define the next step towards developing a real functioning system. Do you need special things made? Do you need to test anything first? Can you specify all of the parts well enough? What else do you need to know?

Team projects – proposed assignments

You can choose your project within or outside this list
If within the list: first come, first serve
If outside the list: email us your proposed project

OK to take a project and modify it along the way (email us if you do that)

(Note: the sooner you choose, the more time you will have to work on it)

Weak lensing: where is the dark matter ?

- measure dark matter in/around galaxy clusters

Exoplanet transits: how many Earth-like planets around stars ?

- transit: planet passes in front of star → drop in brightness
- measure transit frequency → compute planet frequency

Near-Earth Objects: are we in danger ?

- detect NEOs
- measure their orbits
- what size are they ?

How do stars die ? watching and counting supernovae in galaxies

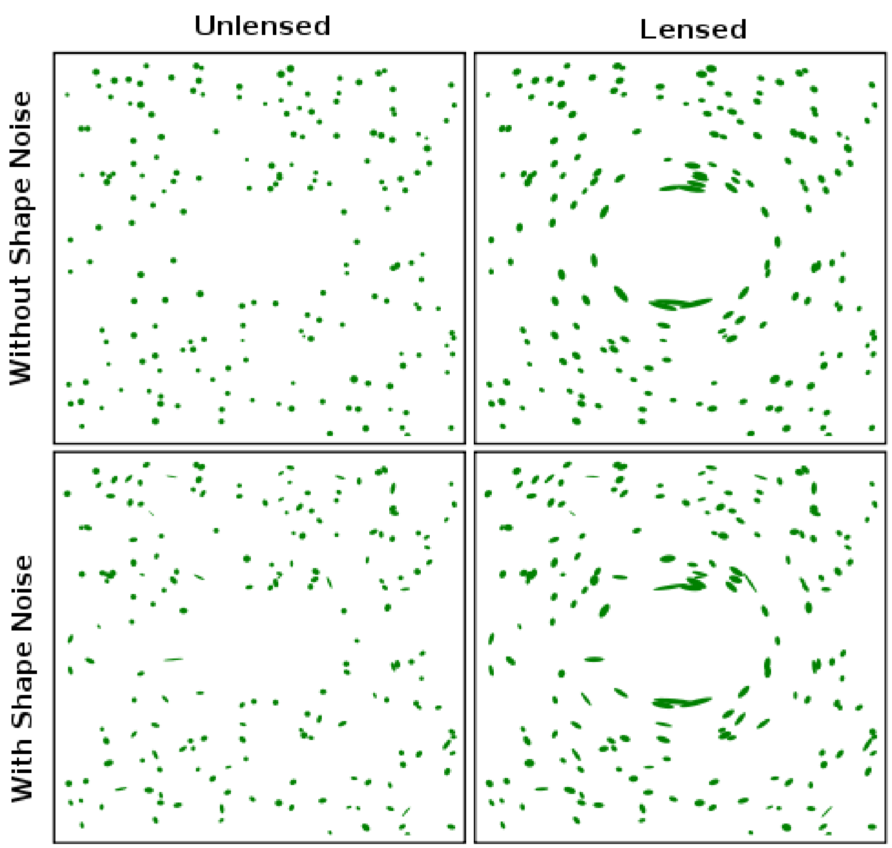
- measure supernovae rate & compare with number of existing stars

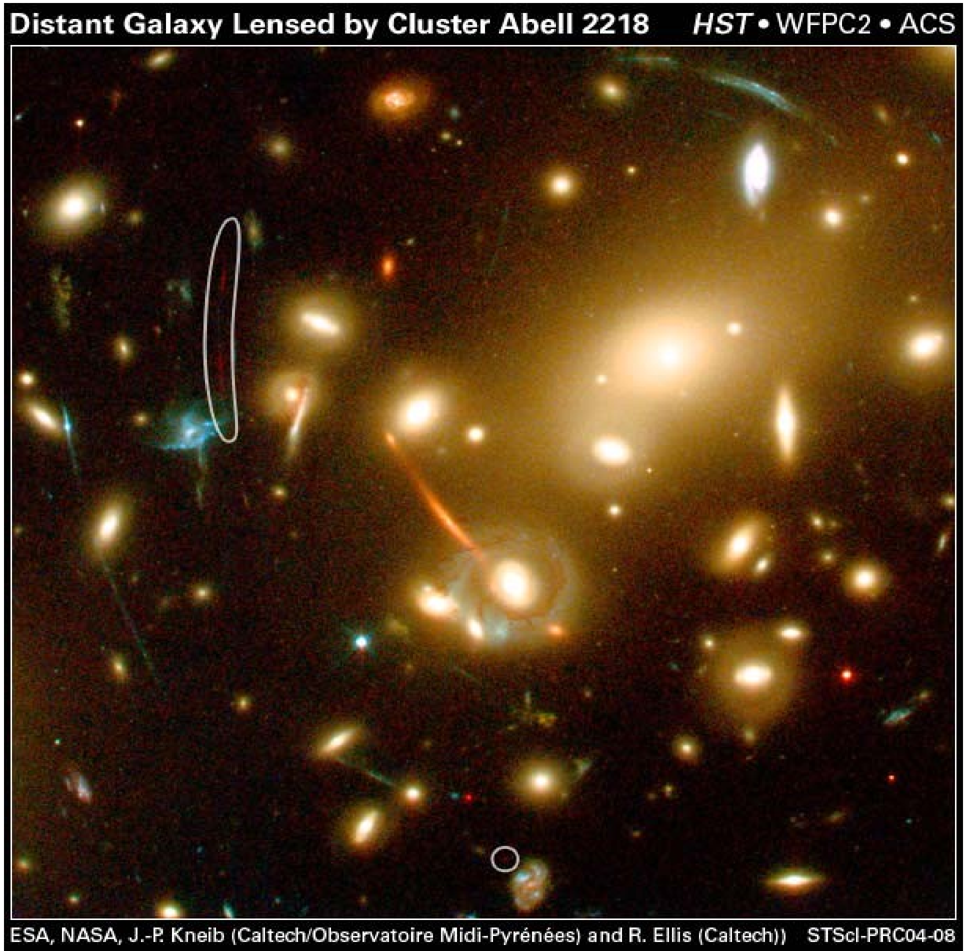
Weak lensing: where is the dark matter ?

- measure dark matter in/around galaxy clusters

Concentrations of dark matter bends light and stretches images of background galaxies. By imaging a large number of background galaxies around a nearby galaxy cluster, it is possible to measure the mass distribution in the nearby galaxy cluster. Most of this mass is dark matter.

GOAL: design an imaging telescope system to measure the distribution of dark matter around a sample of galaxy clusters

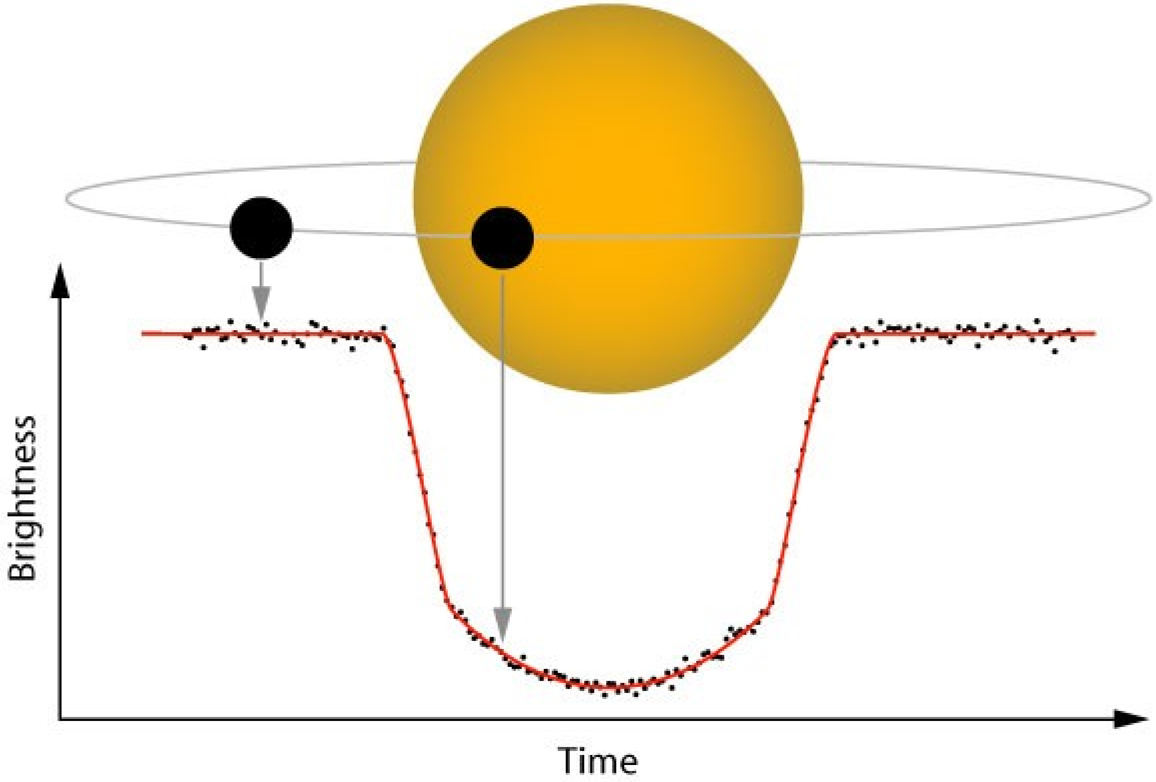




Exoplanet transits: how many Earth-like planets around stars ?

- transit: planet passes in front of star → drop in brightness
- measure transit frequency → compute planet frequency

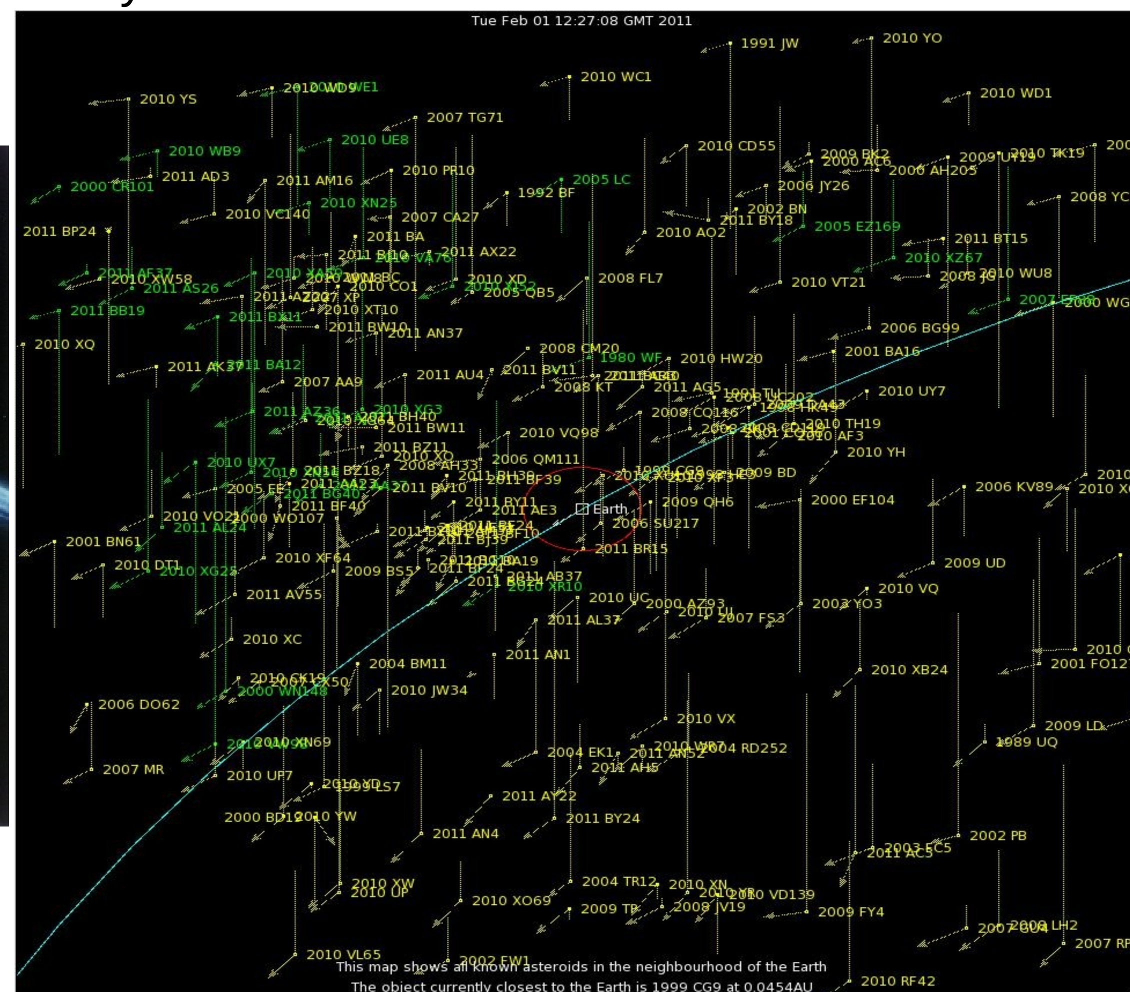
With proper alignment, a planet can pass in front of its host star as viewed from Earth. By looking at a large number of stars for a long period of time, it is possible to measure the statistical distribution of exoplanets in orbital radius / planet radius.



Near-Earth Objects: are we in danger ?

- detect NEOs
- measure their orbits
- what size are they ?

Near-Earth Objects are asteroids with orbits close to Earth's orbit. NEOs could collide with Earth and cause massive destruction. Identification of all NEOs sufficiently large to cause damage is therefore of high importance. Accurate knowledge of their orbits is essential to predict their future position and impact probability with Earth.



How do stars die ? watching and counting supernovae in galaxies

- measure supernovae rate & compare with number of existing stars

With ~10^{10} stars per galaxy, and most stars living several billion years, the death rate of stars in a large galaxy is on the order of 1/year. Some of these stars will produce supernovae (the most massive ones). The supernova rate in galaxies provides a measurable link between number of stars and their lifetimes.

Supernova 1994 D in NGC4526 (HST)