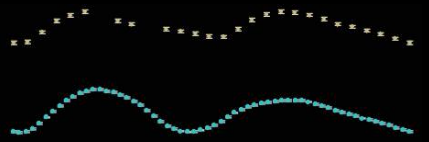
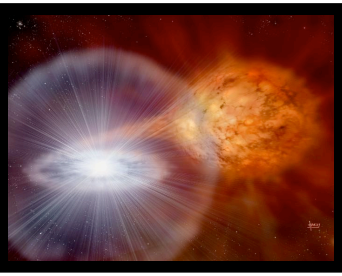
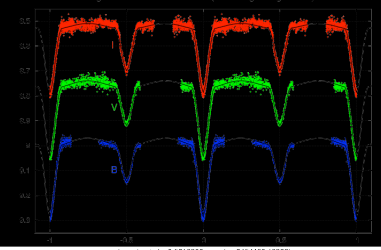
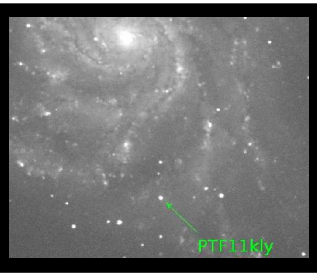
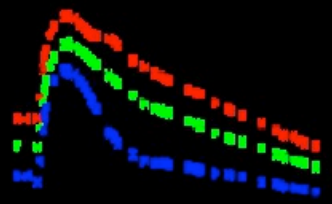
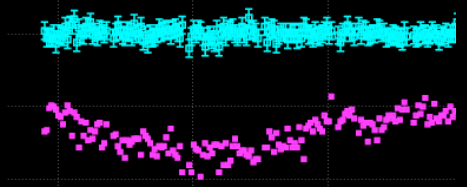
Doing Science with a Small Telescope

Michael Richmond
Physics Department
Rochester Institute of Technology

http://spiff.rit.edu/richmond/asras/aapt_2012/aapt_2012.pdf

asteroids		
variable stars		
supernovae		
exoplanets		

Asteroids

- discover new ones?

  need to go to mag 20 or fainter ...

- measure positions to improve orbits

  88,000 of 580,000 need measurements!

- make light curves

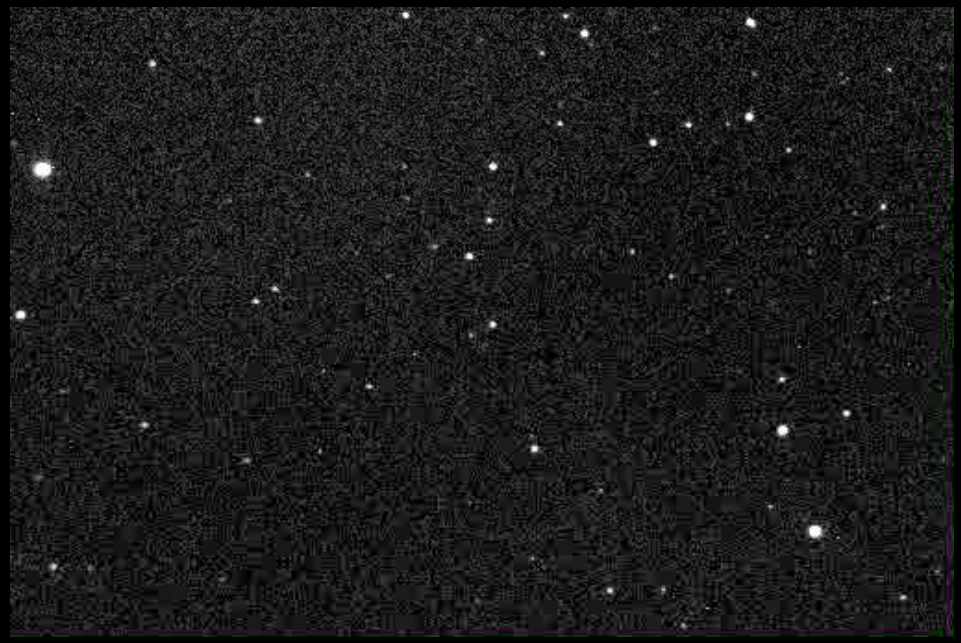
  only 5300 of 580,000 have known periods

Step 1: choose an asteroid which needs additional measurements of position

ftp://ftp.lowell.edu/pub/elgb/astorb.html

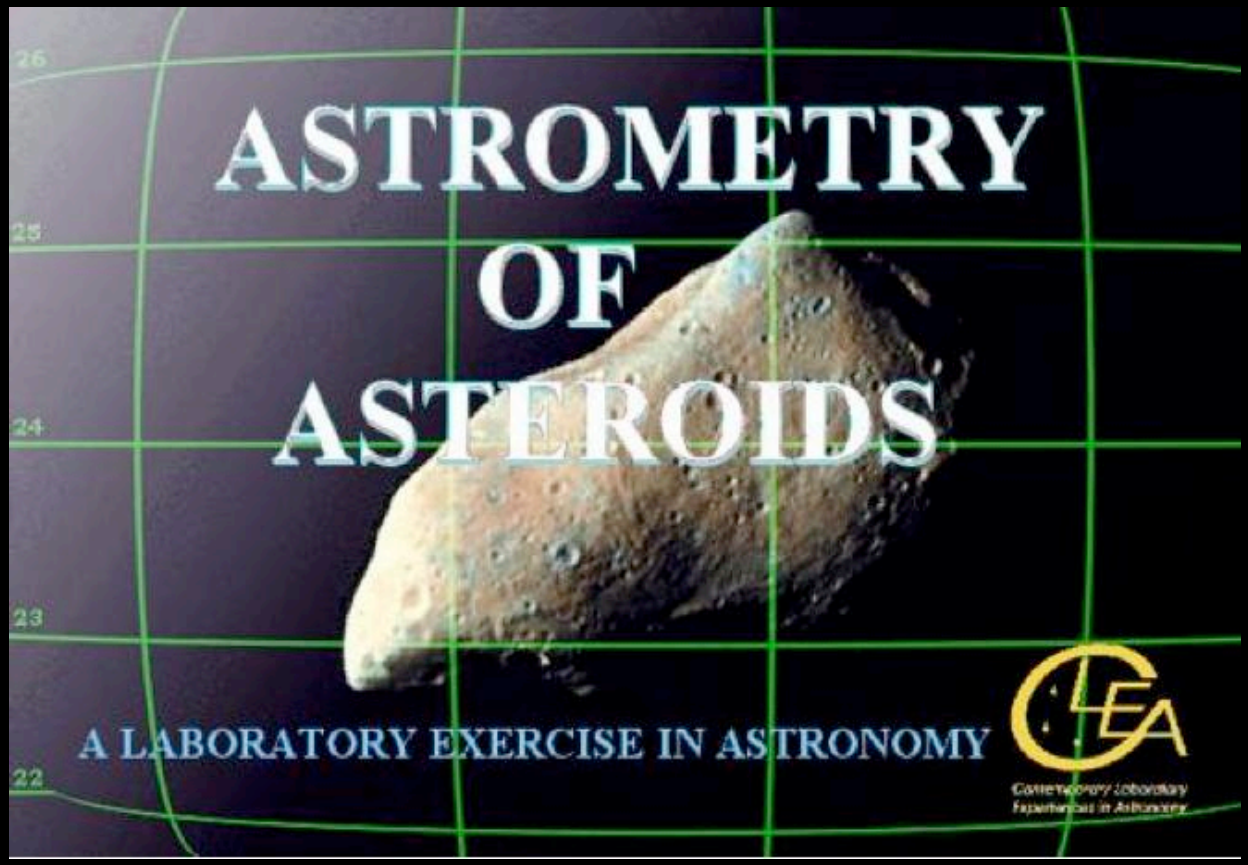
1	Ceres	E. Bowell	3.34	0.12	0.72	848.4	G?	0	0	0	0	0	0
2	Pallas	E. Bowell	4.13	0.11	0.66	498.1	m	0	0	0	0	0	10
3	Juno	E. Bowell	5.33	0.32	0.81	233.9	S	0	0	0	0	0	0
4	Vesta	E. Bowell	3.20	0.32	0.80	468.3	r	0	0	0	0	0	0
5	Astraea	E. Bowell	6.85	0.15	0.83	119.1	S	0	0	0	0	0	9
6	Hebe	E. Bowell	5.71	0.24	0.83	185.2	S	0	0	0	0	0	10
7	Iris	E. Bowell	5.51	0.15	0.85	199.8	S	0	0	0	0	0	0
8	Flora	E. Bowell	6.49	0.28	0.89	135.9	S	0	0	0	0	0	0
9	Metis	E. Bowell	6.28	0.17	0.86			0	0	0	0	0	0
10	Hygiea	E. Bowell	5.43	0.15	0.69	407.1	C	0	0	0	0	0	0
11	Parthenope	E. Bowell	6.55	0.15	0.85	153.3	S	0	0	0	0	0	0
12	Victoria	E. Bowell	7.24	0.22	0.88	112.8	S	0	0	0	0	0	0
13	Egeria	E. Bowell	6.74	0.15	0.75	207.6	G	0	0	0	0	0	0
14	Irene	E. Bowell	6.30	0.15	0.84			0	0	0	0	0	9

Step 2: acquire images of an asteroid one per hour is fine



(this is overkill)

Step 3: measure the position of the asteroid in each image



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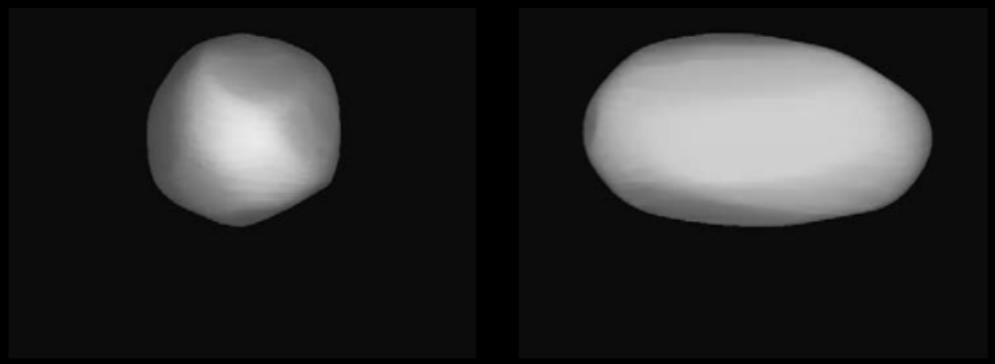
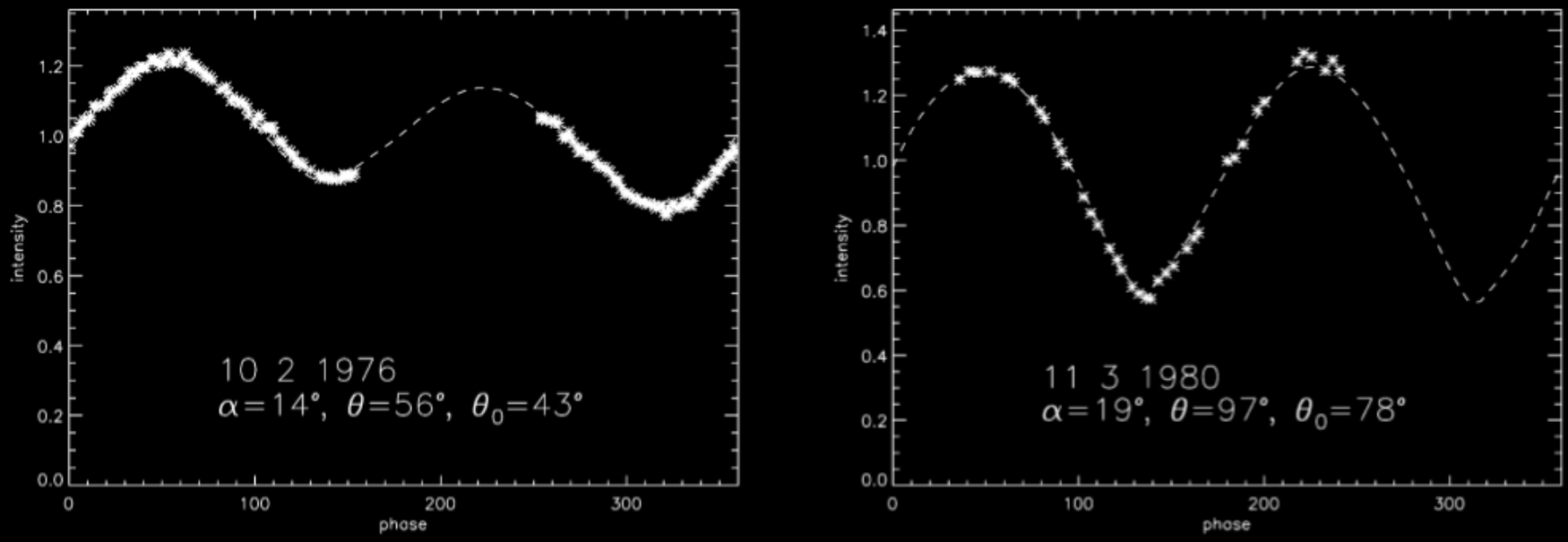


Fig. 27. Shape model of 63 Ausonia.

Torrpa et al., Icarus 164, 346 (2003)



How many asteroids have good rotation periods?

96% of the first 1000 numbered objects

79% of the next 1000

62% of the next 1000

17% of the next 7000

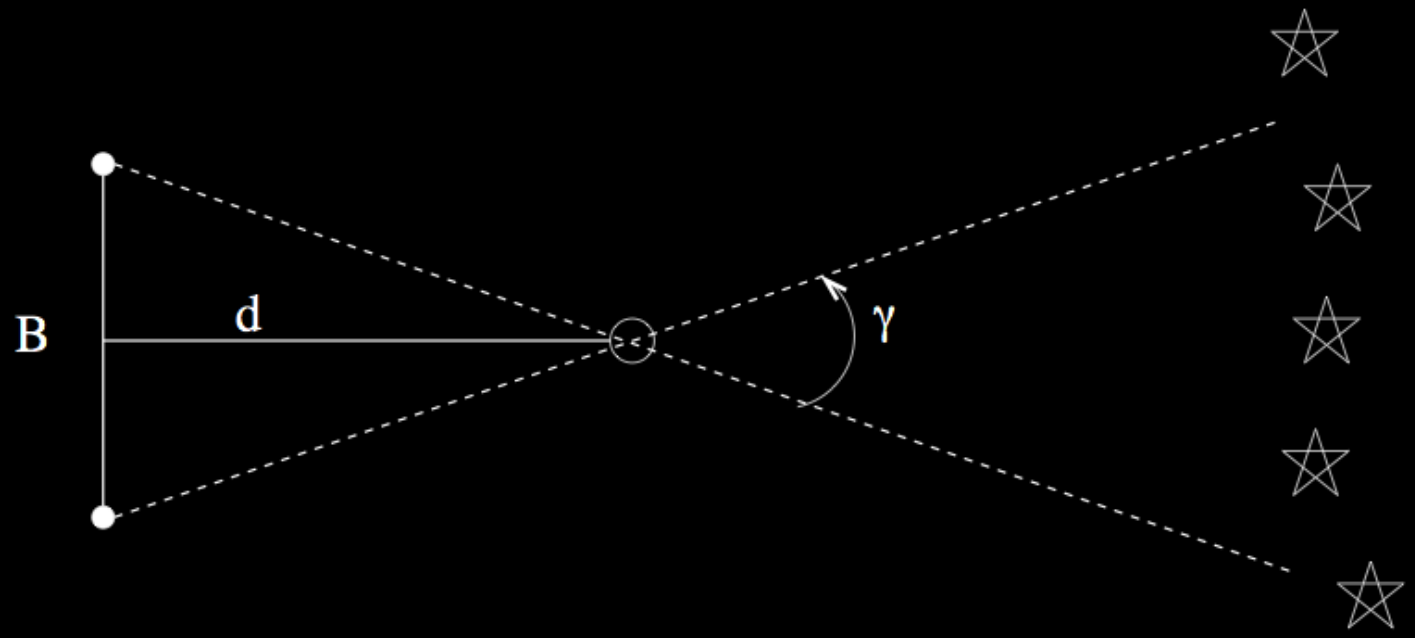
4% of the next 10,000

http://www.minorplanet.info/call.html

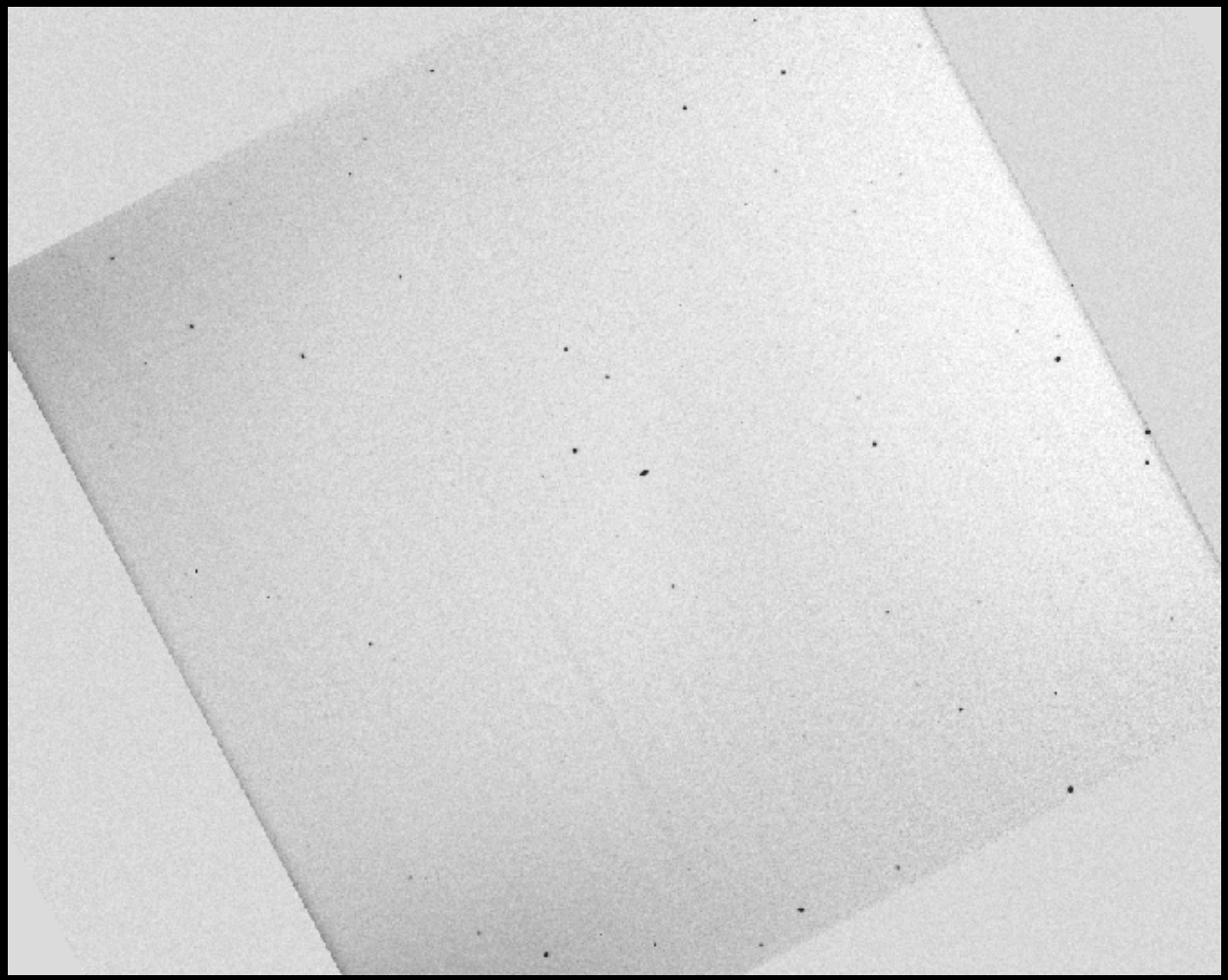
Asteroid parallax -- just for fun

simultaneous images from two locations

use geometry to compute distance



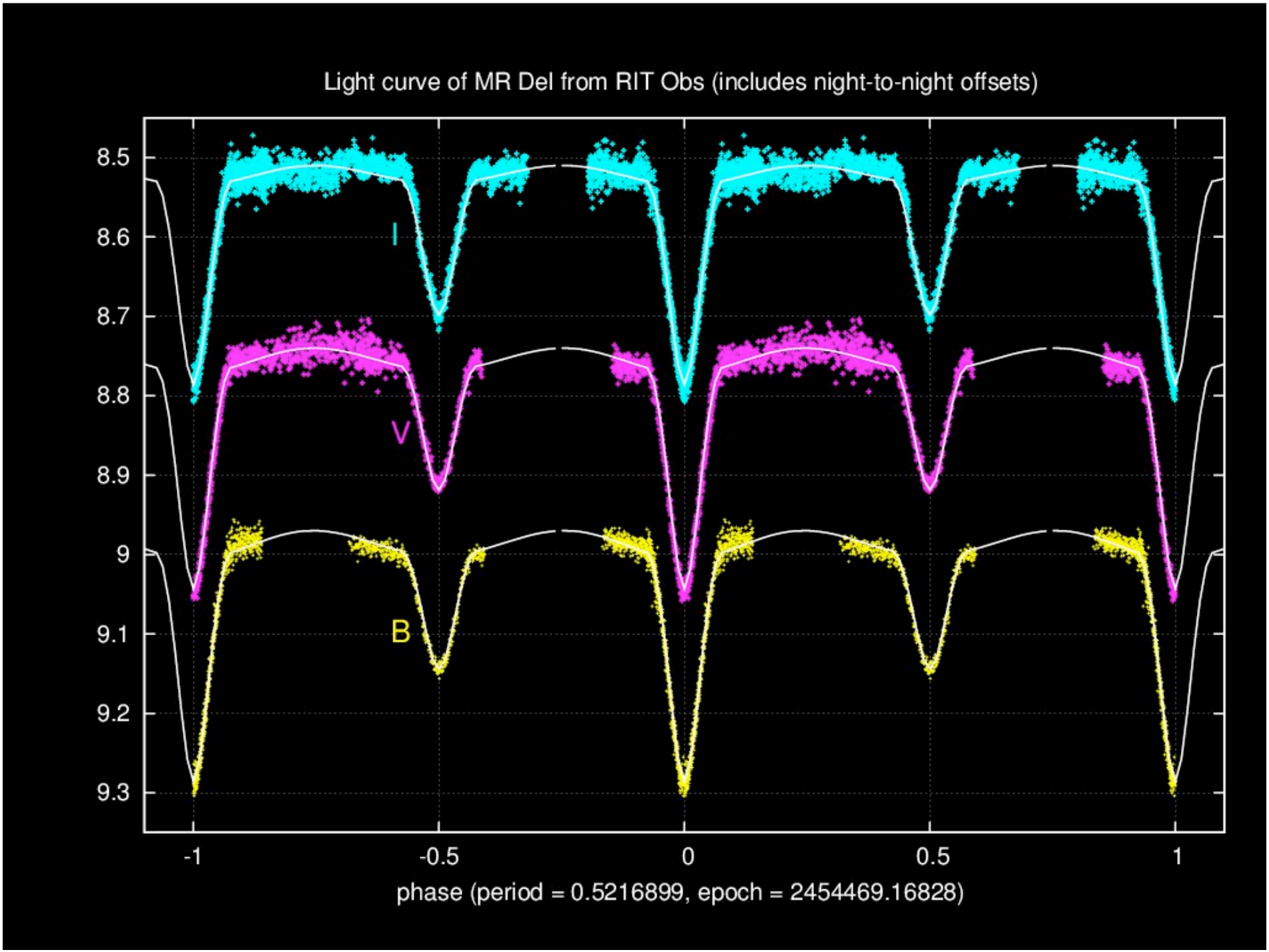
2002 NY40 from Annapolis, MD



2002NY40 from Rochester, NY

Variable stars

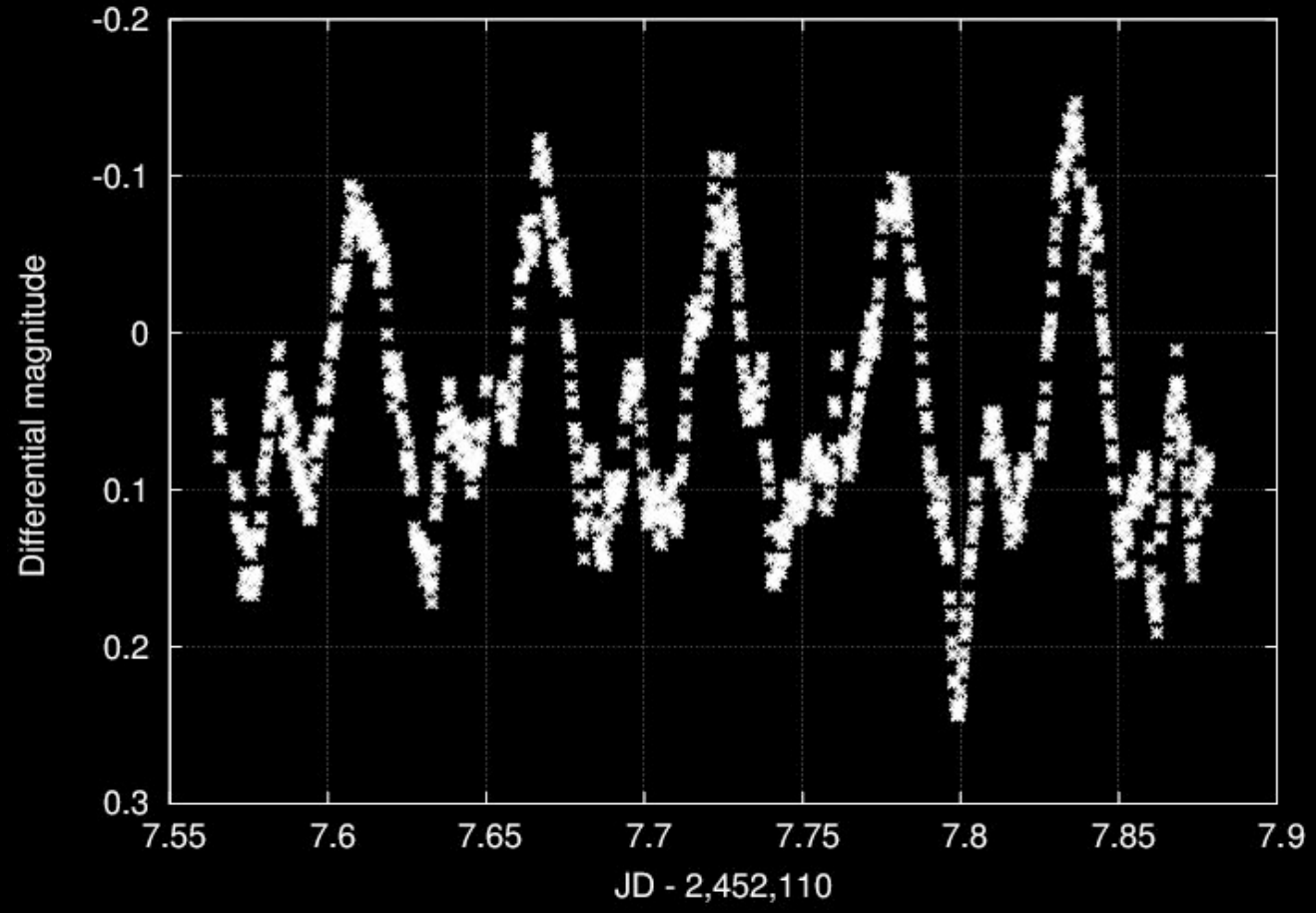
- GCVS contains over 45,000 variable stars
- most have poorly known properties
- multicolor light curves can help to measure
    - stellar radii
    - stellar temperatures
    - stellar masses


Light curve of MR Del from RIT Obs (includes night-to-night offsets)
8.5
8.6
8.7
8.8
8.9
9
9.1
9.2
9.3
I
V
B
-1
-0.5
0
0.5
1
phase (period = 0.5216899, epoch = 2454469.16828)

Choose the type of star which fits your timescale

Variable type	Freq of measurements
Long-period variable	one per week
RR Lyrae	many per night (on any night)
eclipsing binary	many per night (on selected nights)
cataclysmic variable	many per night (only during outburst)

Cataclysmic variable WZ Sge during 2001 outburst
RIT Observatory, 10-inch telescope



- AAVSO

  http://www.aavso.org/

- Center for Backyard Astrophysics

  http://cbastro.org/

Supernovae

- discover new ones?

  hundreds found each year

  most are faint, embedded in host galaxy

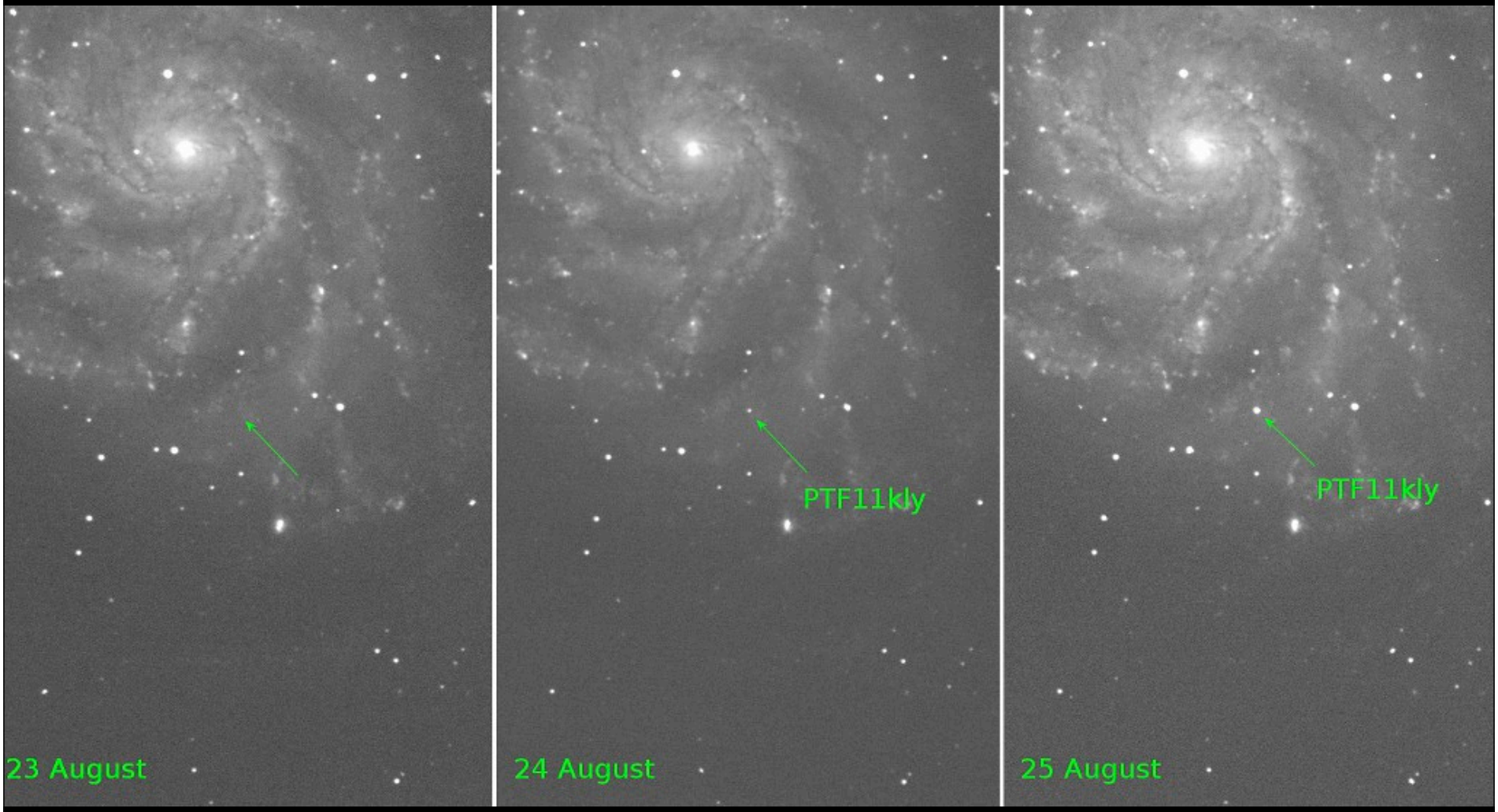
- followup photometry of known events

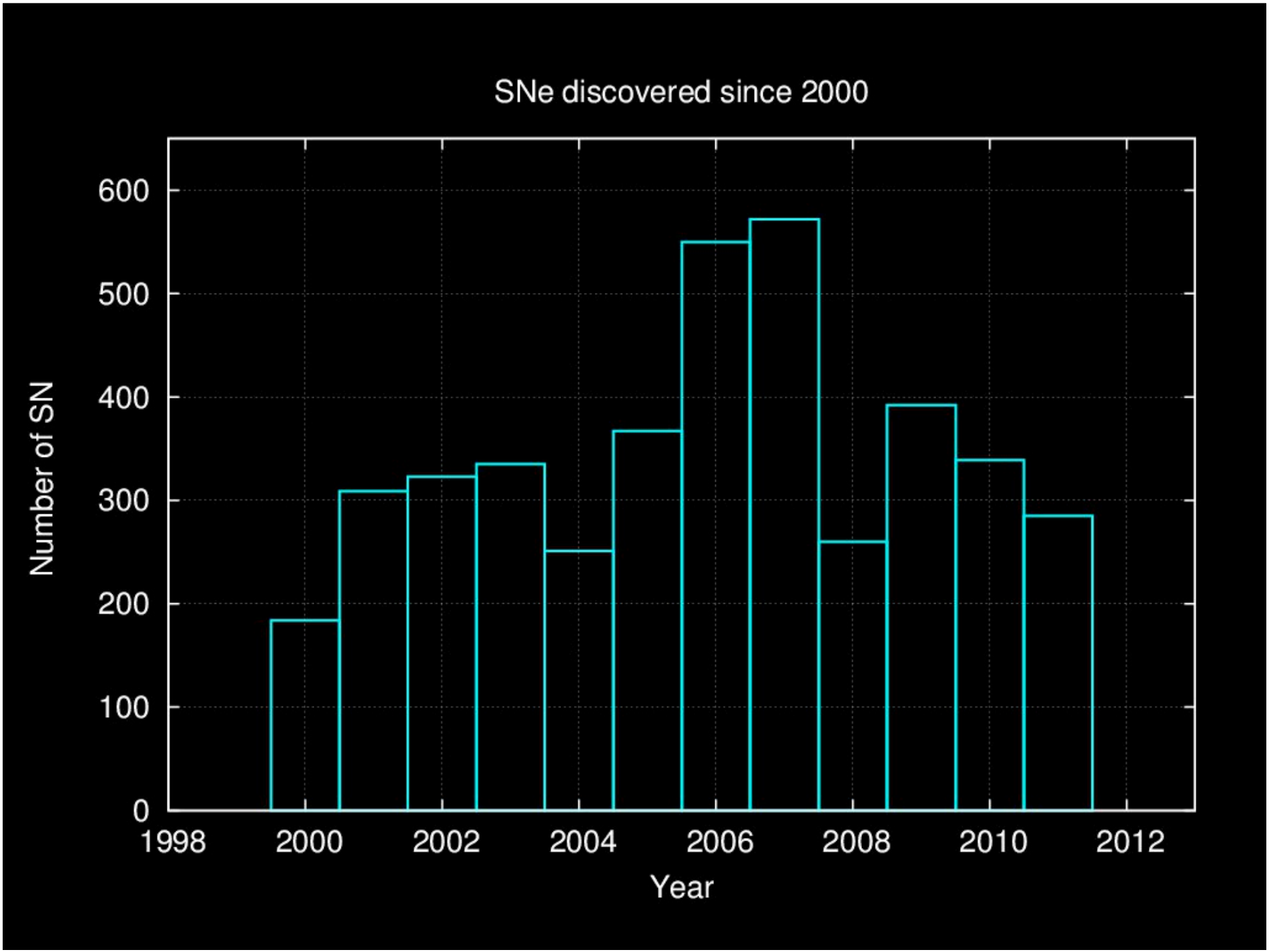
  plenty are bright, mag < 13.7 at peak

  need photometric filters

  watch out for effects of wierd spectra!

Palomar Transient Factory discovers SN 2011fe in M101




SNe discovered since 2000
Number of SN
Year
0
100
200
300
400
500
600
1998
2000
2002
2004
2006
2008
2010
2012

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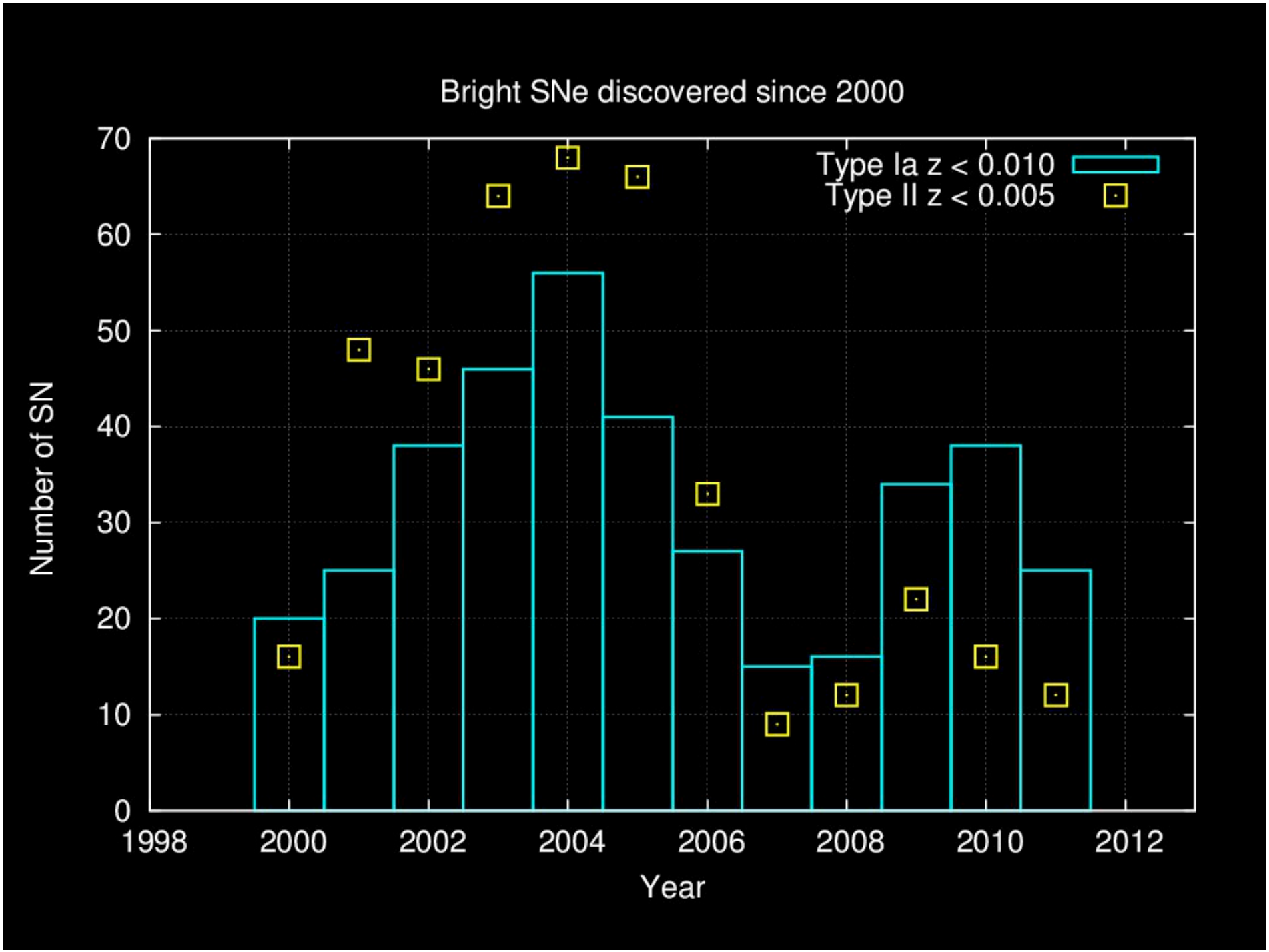
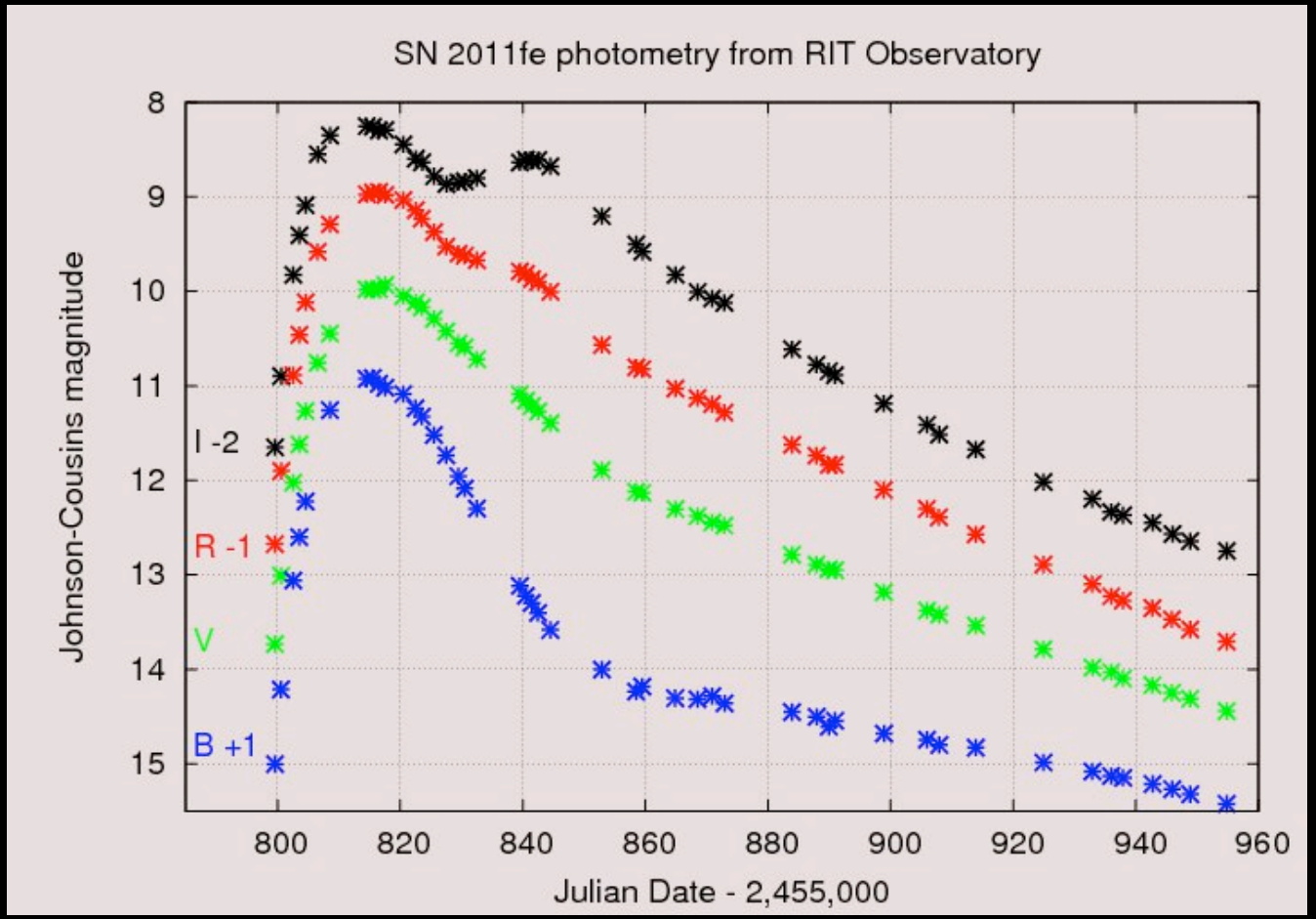

Bright SNe discovered since 2000
Type Ia z < 0.010
Type II z < 0.005
Number of SN
Year
0
10
20
30
40
50
60
70
1998
2000
2002
2004
2006
2008
2010
2012

Measurements made with a 12-inch telescope



- Central Bureau for Astronomical Telegrams

  (also home of IAU Circulars)

  http://www.cbat.eps.harvard.edu/index.html
- Astronomer's Telegram

  http://www.astronomerstelegram.org/
- Dave Bishop's supernova site

  http://www.rochesterastronomy.org/supernova.html
- notes on novae and supernovae

  http://spiff.rit.edu/richmond/sne/aavso/nova_sn.html

Exoplanets

- transits can be detected with small telescopes
- discover new ones?

  requires survey of thousands of stars
- followup photometry of known events

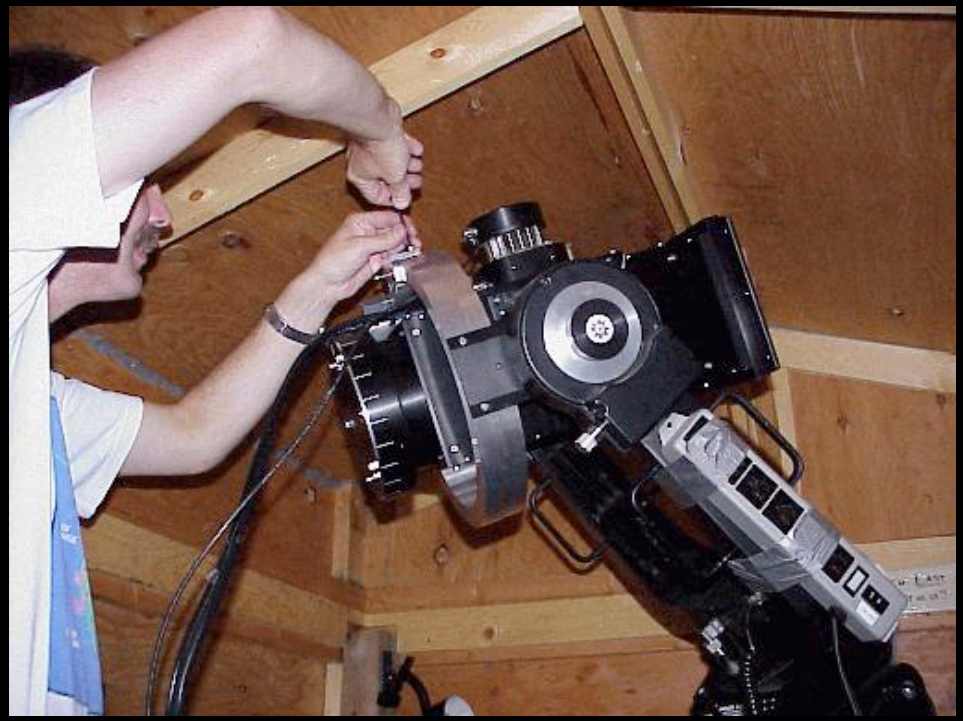
  need high-precision photometry

  one good night is all it takes

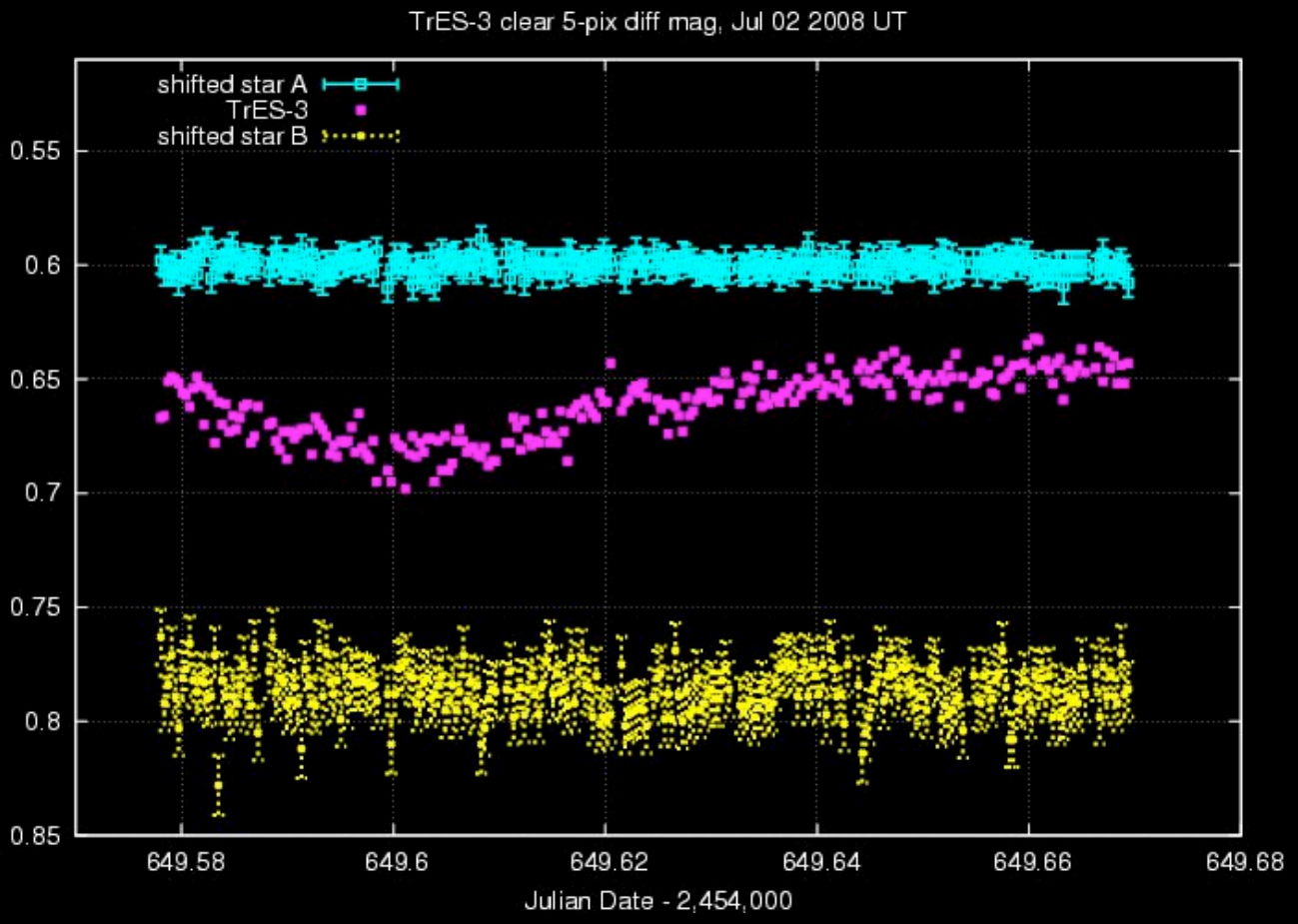
  transit timing measurements are valuable

The first transit observations were made with the STARE 4-inch telescope in 1999

Charbonneau et al., ApJ 529, L45 (2000)



Photometry of TrES-3 with a 12-inch telescope



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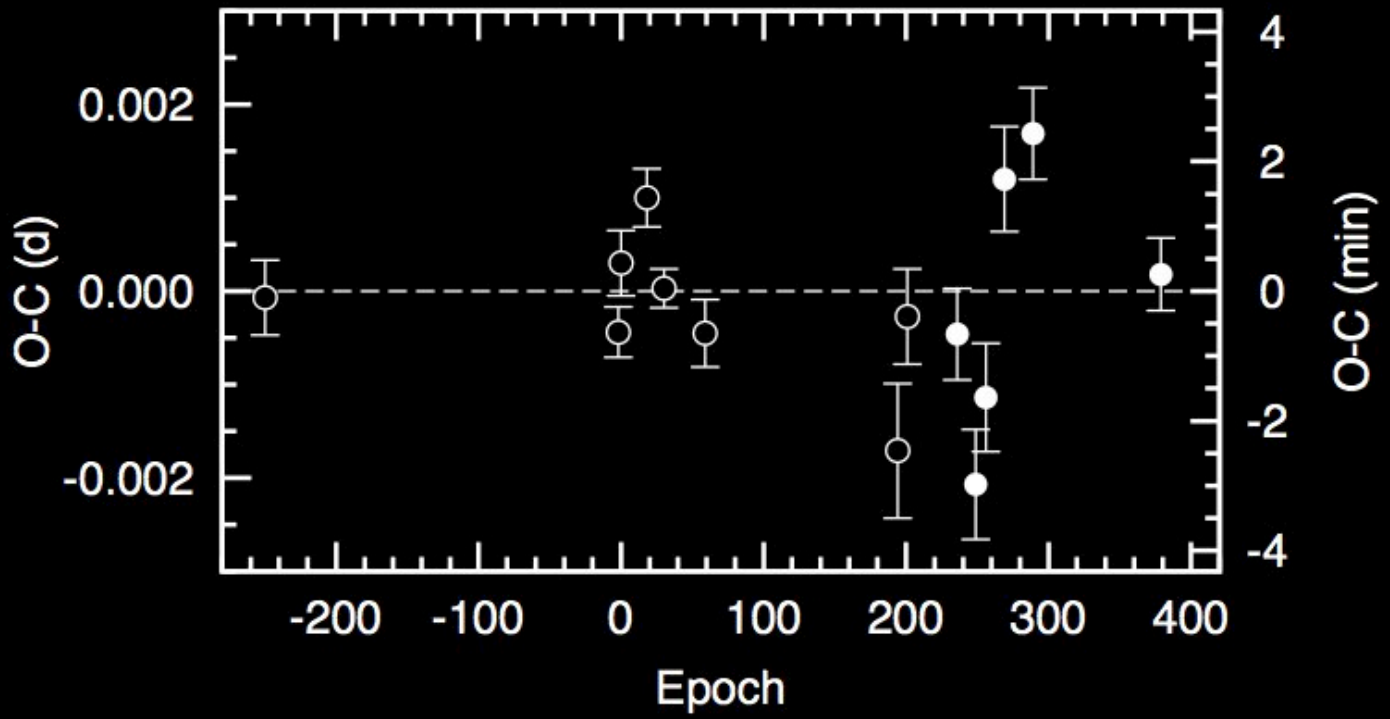
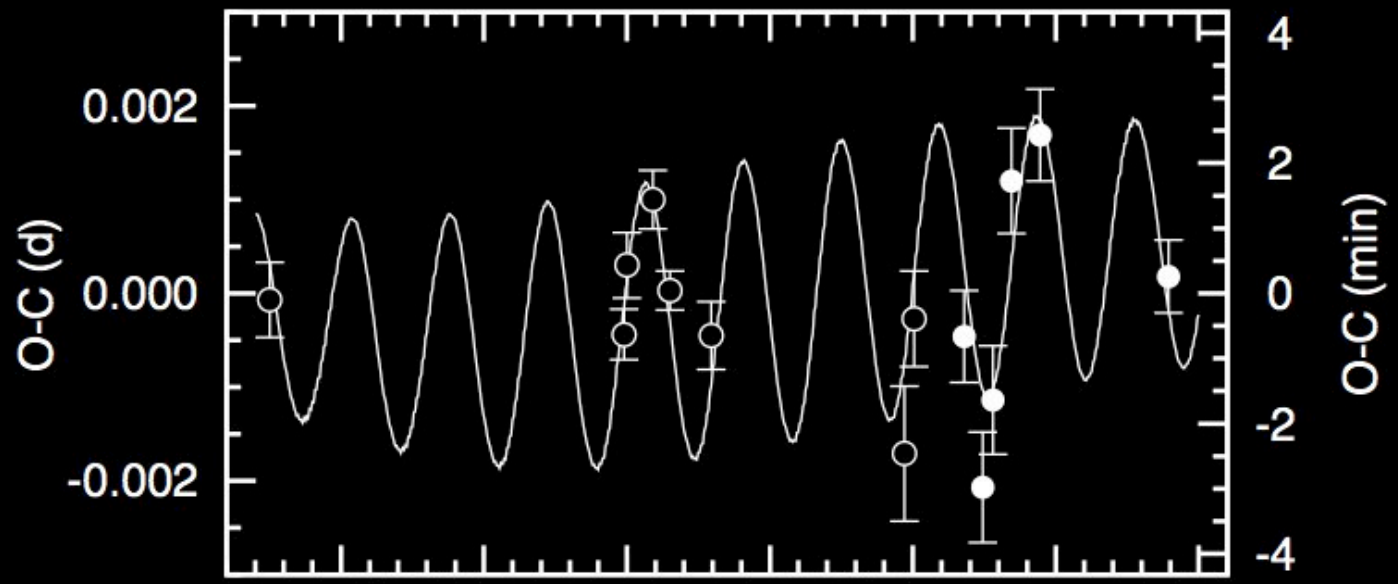
Transit timing variations in WASP-3b

Maciejewski et al., MNRAS 407, 2625 (2010)



Model shows effect of second planet with 15 Earth masses (transiting planet has 560 Earth masses)



- TransitSearch.org

  http://www.transitsearch.org/
- Exoplanet transit database

  http://var.astro.cz/ETD
- Amateur exoplanet archive

  http://brucegary.net/AXA/x.htm
- ensemble photometry

  http://spiff.rit.edu/ensemble/

Easy projects

- astrometry of known asteroids
- photometry of variable stars
- detecting exoplanet transits

Intermediate projects

- asteroid light curves
- detailed analysis of variable star light curves
- photometry of known supernovae
- exoplanet timing measurements

Difficult projects

- finding new asteroids
- finding new supernovae
- finding new exoplanets