Space (and Ground Based) Exoplanet Missions Greg Laughlin UCSC

25-year Timeline of 55 Cancri RV Observations





















Jovian Satellite System

In situ formation or migration?

GJ 687b -- The *least* extraordinary planet found to date.





- $M \sin(i) = 17 M_{Earth}$
- •P=38 d circular orbit
- •M3 V primary (Nearest star north of +60 dec)



Spitzer







Planets are ordered on the *x*-axis by the equilibrium temperature, T_{eq} , computed with the assumption that they are A=0 blackbodies that re-radiate from the full planetary surface. Measured secondary eclipse depths (in bands ranging from Kepler's optical bandpass to 8µm) are expressed as ratios of the observed eclipse depth in the band relative to the expected depth in the band under the assumption that the planet is a uniformly re-radiating A=0 blackbody.

$$T_{\rm eq} = (R_{\star}^{1/2}T_{\star})/((2a)^{1/2}(1-e^2)^{1/8})$$

Central Limit Theorem

The central limit theorem states that a sufficiently large number of iterates of independent random variables, each with a well-defined expected value and well defined variance, will be approximately normally distributed.







Spitzer is subject to serious systematic error. Definitive results will come from JWST.

Exoplanet News from the AAS meeting (New York Times)

"The discovery of a planet, not much larger than Jupiter, outside the solar system was reported yesterday by a Swarthmore College scientist at an American Astronomical Society meeting."

"The object is a dark companion of a dim star some 36,000,000,000,000 miles away. It is called Barnard's star"

Another Solar System Is Found 36 Trillion Miles From the Sun

The discovery of a planet, not ported his discovery at the somuch larger than Jupiter, out side the solar system was reported yesterday by a Swarth more College scientist at ar American Astronomical Society meeting. The object is a dark companion of a dim star some 36,-000,000,000,000 miles away. It probably does not bear life as is called Barnard's Star. Named Barnard's Star by its planet is too large and too cold.

discoverer, Dr. Peter van de Kamp who directs Swarth-Kamp's report, the new planet more's Sprout Observatory in occupies an orbit four times Pennsylvania, the new planet is farther from its parent star the third such body discovered than the distance between earth outside the solar system but the and the sun. Also, the luminmost nearly planet-sized one of osity of Barnard's Star is only all.

This means that there are sandths that of the sun's. now three identified "solar systems" besides the one inhabited that the new planet receives by earth. One, consisting of at less than three hundred-thouleast one planet and a sun sandths as much energy over a named 61 Cygni, was discov-square foot as the earth gets ered in 1943. Another, named from the sun.

Lalande 21185, was found in 1960. The planets in those two systems, however, are on the out a telescope because it is so borderline between planetary dim. Likewise, the new planet bodies and stars, both having is also invisible—even with a masses of about one one-nuntelescope. Dr van de Kamp discovered it through analyzing Barnard's Star is much the wobbles its parent star smaller, only one seven-hunmakes, in its movements across the heavens.

one and a half times the mass. It is the makens. one and a half times the mass. Those wobbles are created by of Jupiter, or nearly 500 times the gravitational attraction belas massive as the earth, actween Barnard's Star and its cording to Dr. van de Kamp. The Swarthmore scientist reonce every twenty-four years.

So slight are the perturbations in Barnard's Star's trajectory, however, that they could be detected only through a painstaking study of thousands of photographs of the star over a period of nearly 50 years.

The new finding adds support to the conviction of astronomers that a great many solar systems exist, some of them possibly supporting life. "The finding was called 'exciting' by Dr. Kenneth Franklin of the American Museum-Hayden Planetarium. He noted, however, that Barnard's Star b probably does not bear life as Earth knows it because the new planet is too large and too cold."

"The new finding adds support to the conviction of astronomers that a great many solar systems exist, some of them possibly supporting life."

A Planetary System Orbiting Barnard's Star?



FIG. 3. Barnard's star: Apparent orbits of the two perturbations with circular orbits, and P = 26 years and P = 12 years.







|93|



2007



A planet, as depicted in this restirring, orbits the habitable zone of a star 20 light years from Earth, meaning it could have water on its series.

2010

36 Light-Years From Here, New Hope for an Earth-Like Planet



An illustration of what the planet orbiting the Survive star HD IBS12b might look like. By DENNIS OVERBITE

Published September 12, 2011

European astronomers said Monday that they had found what might be the best candidate for a Goldilocks planet yet: a lump of something about 3.6 times as massive as the Earth, circling its star at the right distance for liquid water to exist on its surface — and thus, perhaps, to host life, as we narrowly imagine it.

201

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2014 (Kepler 168f)



SS Transiting Exoplanet Survey Satellite

NLS-II LV

Observatory



High Earth Orbit (HEO)
2:1 Resonance with Moon's Orbit Orbital LEOStar-2
 Instrument-in-the-loop attitude control Science Instrument

Four Wide Field-of-View CCD Cameras

Orbiz

- 24°x 24°Field-of-View
- Spacecraft interfaces well defined



Project Overview

- Transiting exoplanet discovery mission
- 2 year all sky survey
- Identifies best targets for follow-up characterization
- Deep Space Network (DSN) utilization
- Category II, Class C
- LRD: August 2017
- PI Cost Cap: \$228.3 M (RY\$)



TESS Strategy

