ASTRO 5: LIFE IN THE UNIVERSE

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LECTURE #2: DISCUSSION *"ALIEN LIFE – WILL WE KNOW IT WHEN WE SEE IT?"*

THIS POWERPOINT JUST HITS SOME HIGHLIGHTS AND FOLLOW-UPS TO THIS GENERAL DISCUSSION AND NEW RESEARCH ON THESE QUESTIONS

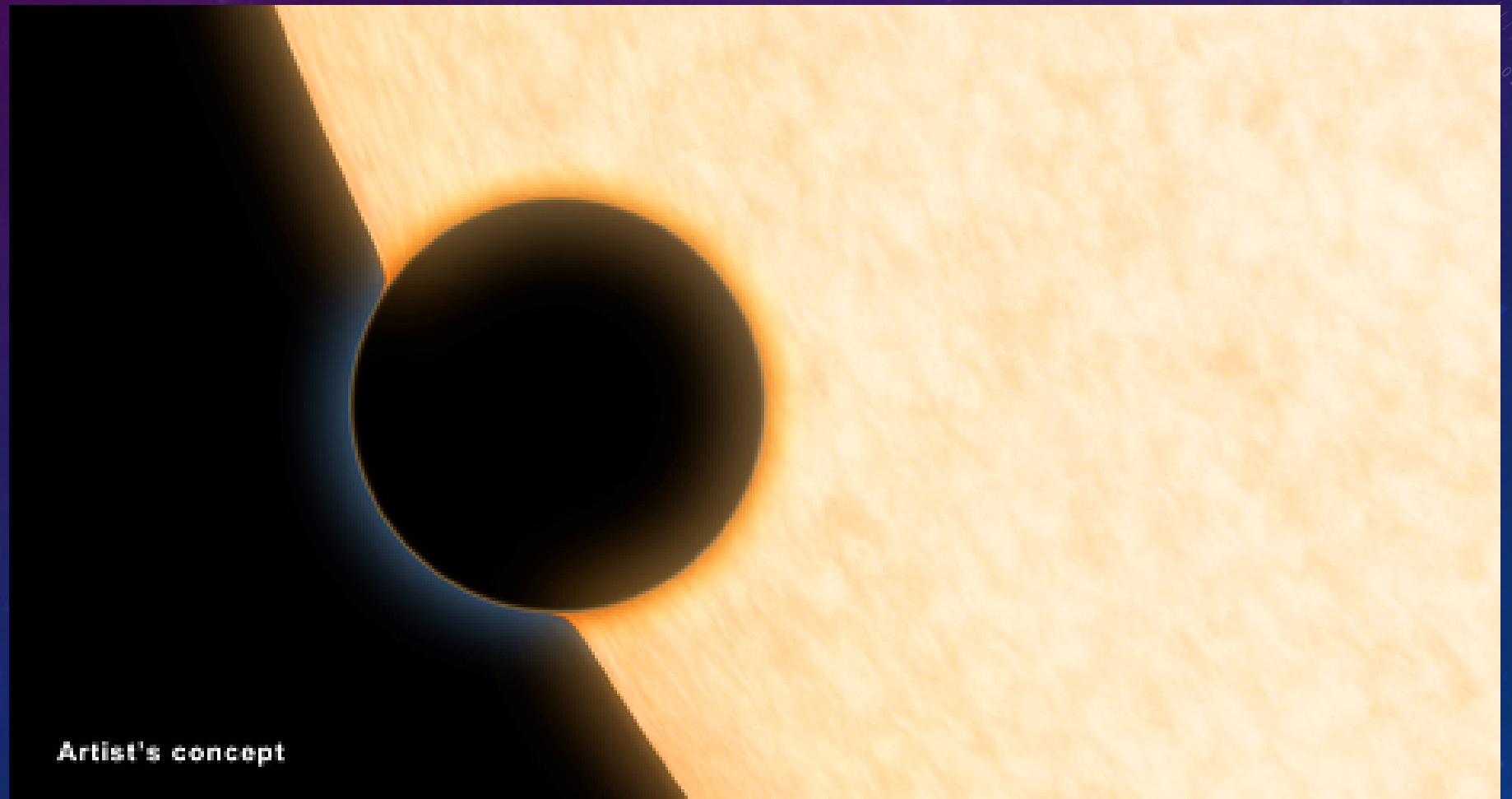
- Our discussion centered around the “World of Science” panel discussion “Alien Life: Will we know it when we see it?” (1hr 33min) recorded in 2014 after the conclusion of the main Kepler mission (when the gyro’s failed! Subsequent data was more “random” in where Kepler was looking)
- Here is the Zoom recording of our lecture

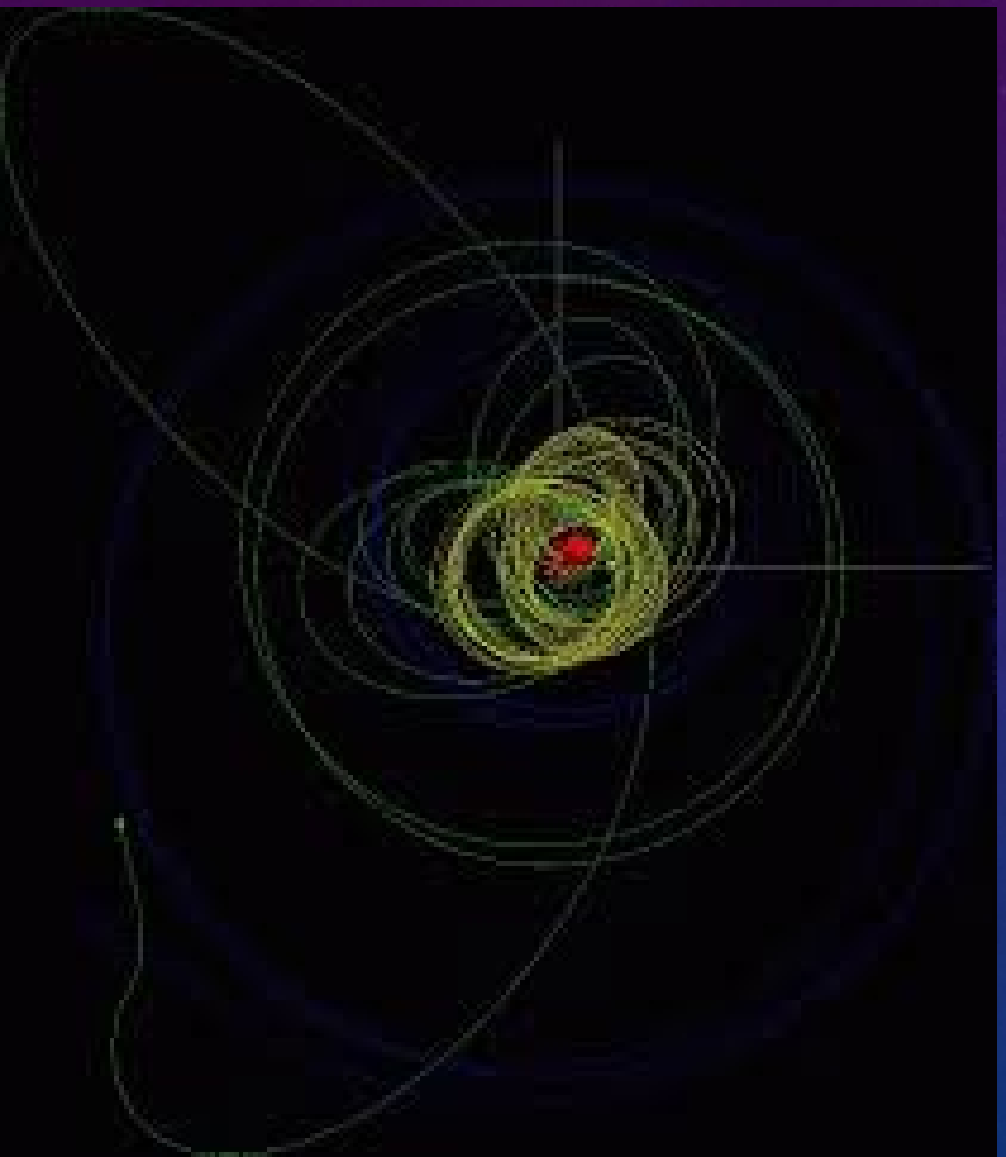
THE KEPLER MISSION: USING TRANSITS TO FIND EARTH SIZED PLANETS

- The Doppler method is poorly suited to find the tiny wobble in the parent star's motion around the common center of mass of the system, for small Earth-sized planets
- Our strongest interest is in finding life-suitable planets, which are most likely to be Earth sized.
- So we needed a way to find small rocky Earth-sized planets. Tough to do from the ground! Hence:
- The Kepler Mission…

THE KEPLER MISSION TOOK NEAR CONTINUOUS IMAGES OF A LARGE REGION BORDERING CYGNUS AND LYRA, MONITORING 150,000 STARS FOR SUBTLE CHANGES IN BRIGHTNESS

TRANSITS CAUSE TINY DIPS IN THE TOTAL LIGHT OF THE SYSTEM. BY BEING IN SPACE WITH NO ATMOSPHERE TO COMPLICATE THE BRIGHTNESS MEASURING (“PHOTOMETRY”), KEPLER COULD MEASURE DIPS DUE TO PLANETS EVEN SMALLER THAN EARTH

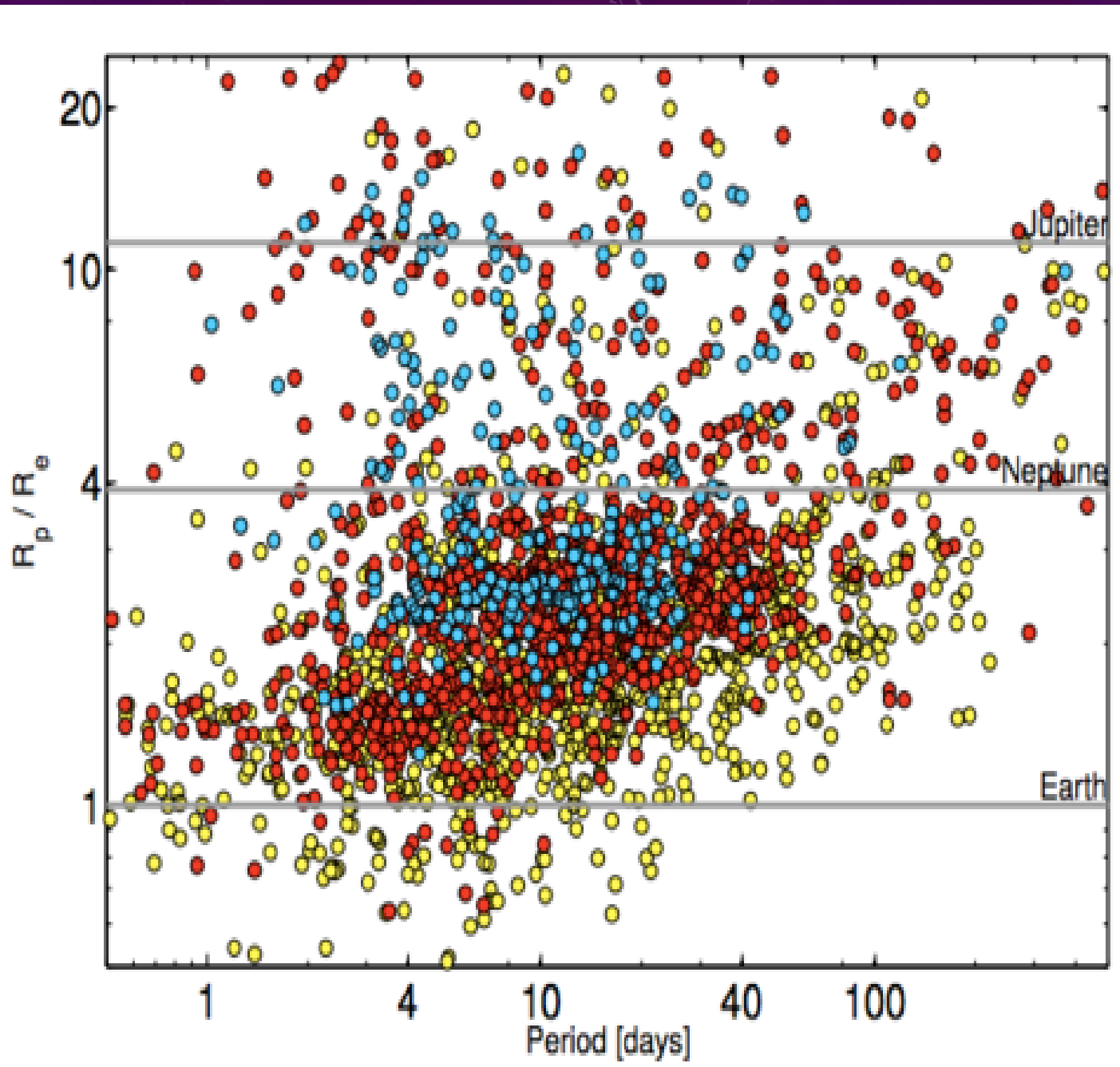




IN ORDER TO CONFIRM A REAL DISCOVERY, KEPLER SCIENTISTS REQUIRED THE DIPS TO HAVE ~REPRODUCABLE SHAPES AND OCCUR IN A PRECISE REGULAR PERIOD.

THEY COULD NOT HOPE TO FIND PLANETS IN CHAOTIC ORBITS SUCH AS YOU MIGHT FIND IN CLOSE BINARY STAR SYSTEMS

SORRY, LUKE…



MOST KEPLER DISCOVERIES WERE LARGER THAN EARTH. ONLY ABOUT 10% WERE EARTH SIZED AND SMALLER. SIZE BIAS DUE TO THE TINY TRANSIT DEPTHS IS A SIGNIFICANT FACTOR

EARLY ESTIMATES FROM THIS TALK, FROM THE KEPLER DATA, SUGGESTED THE NUMBER OF ~EARTH SIZED PLANETS

- … which were inside their star's "habitable zone" (the zone where, given the right kind of atmosphere, liquid water was possible), to be somewhere between 1 to 5 billion in our Galaxy!
- That's a lot
- Since then, new estimates have come down a factor of 10.

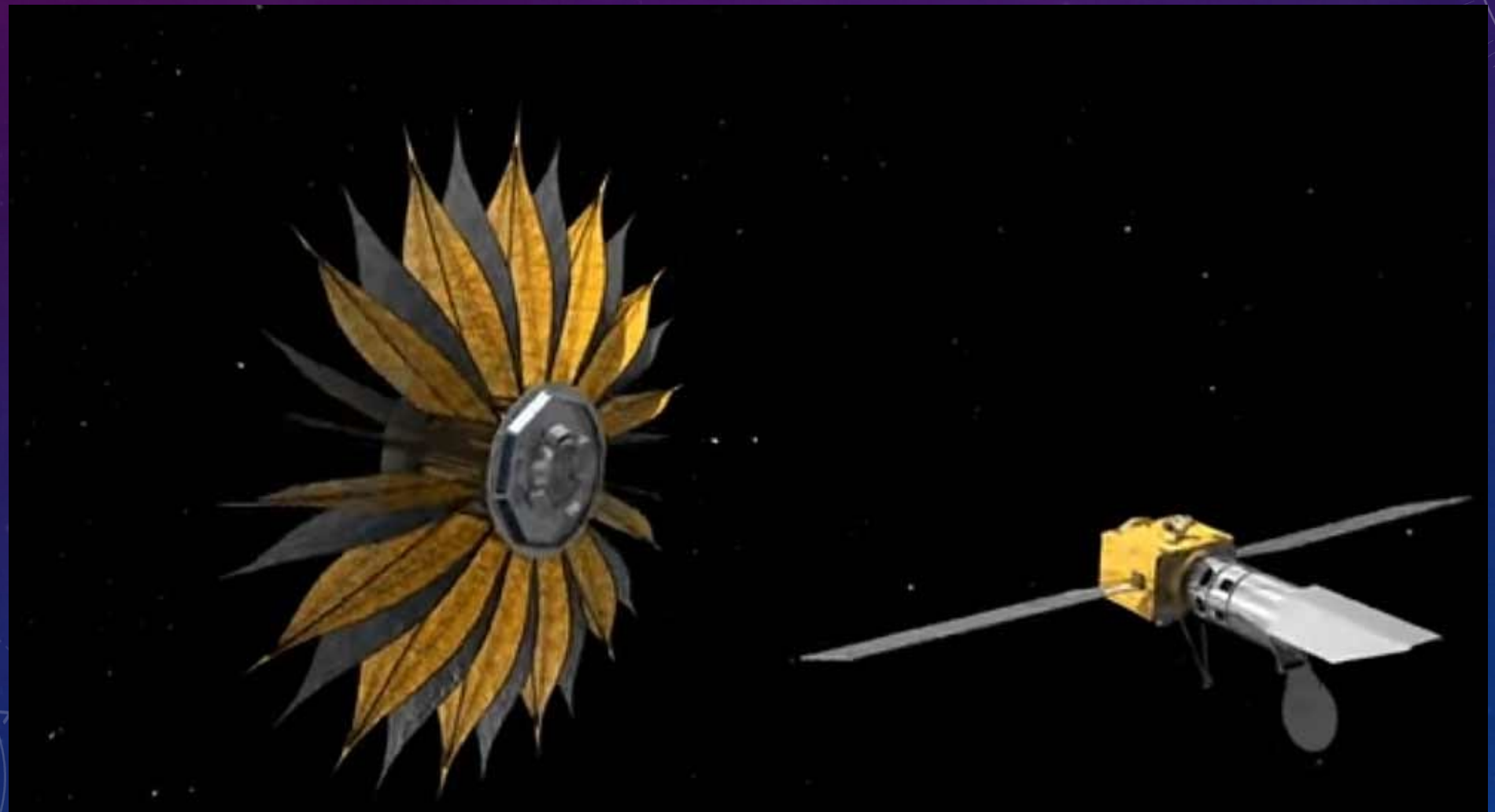
BRYSON *ET AL.* 2020 FIND ~50% OF G,K MAIN SEQUENCE STARS HAVE ~EARTH SIZED PLANET INSIDE THEIR HABITABLE ZONE.

~300 MILLION IN THE GALAXY

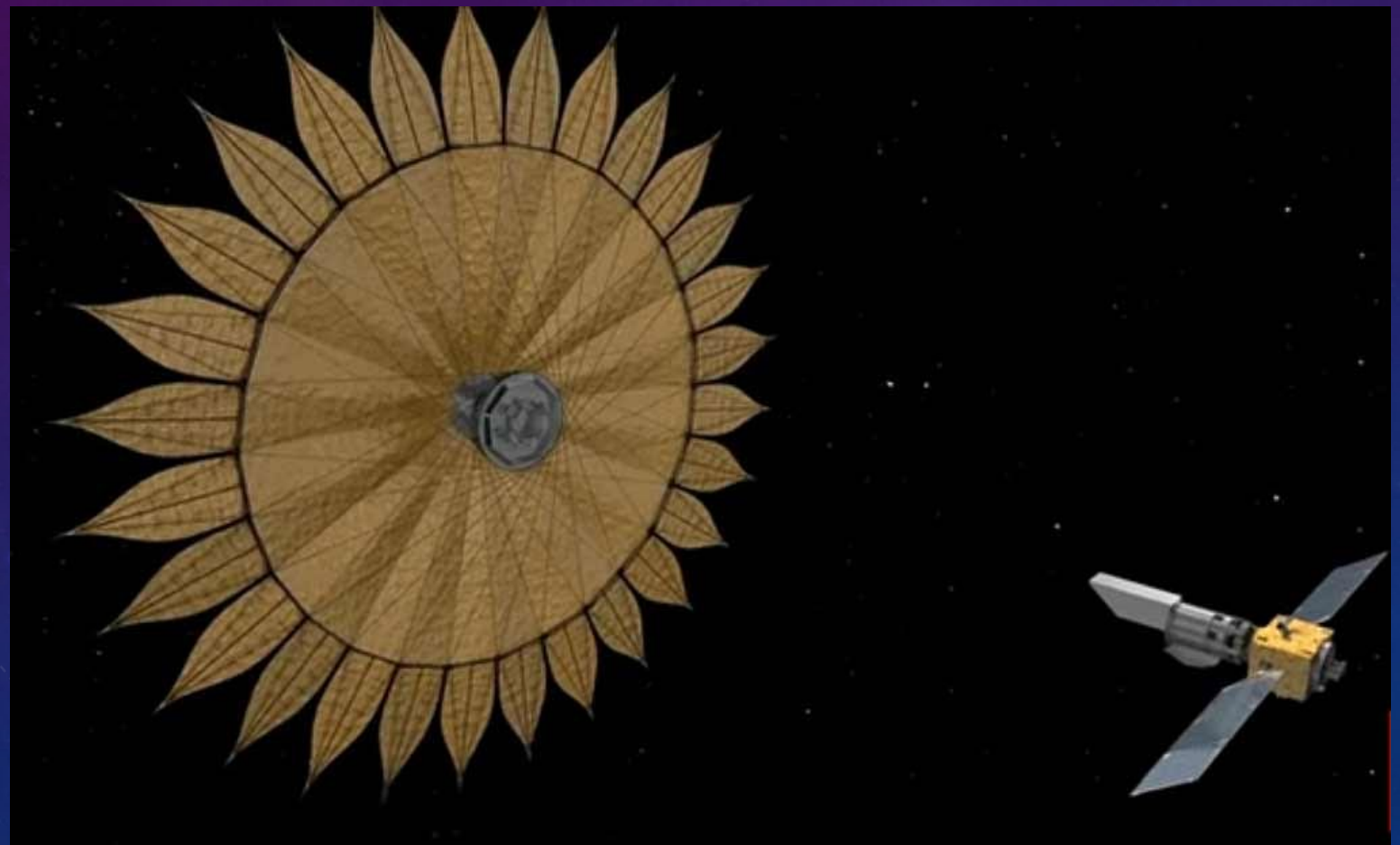
(their abstract) "We present occurrence rates for rocky planets in the habitable zones (HZ) of main-sequence dwarf stars based on the Kepler DR25 planet candidate catalog and Gaia-based stellar properties. We provide the first analysis in terms of star-dependent instellation flux, which allows us to track HZ planets. We define $\eta_\oplus$ as the HZ occurrence of planets with radius between 0.5 and 1.5 $R_\oplus$ orbiting stars with effective temperatures between 4800 K and 6300 K. We find that $\eta_\oplus$ for the conservative HZ is between 0.37+0.48−0.21 (errors reflect 68\% credible intervals) and 0.60+0.90−0.36 planets per star, while the optimistic HZ occurrence is between 0.58+0.73−0.33 and 0.88+1.28−0.51 planets per star. These bounds reflect two extreme assumptions about the extrapolation of completeness beyond orbital periods where DR25 completeness data are available. The large uncertainties are due to the small number of detected small HZ planets. We find similar occurrence rates using both a Poisson likelihood Bayesian analysis and Approximate Bayesian Computation. Our results are corrected for catalog completeness and reliability. Both completeness and the planet occurrence rate are dependent on stellar effective temperature. We also present occurrence rates for various stellar populations and planet size ranges. We estimate with 95% confidence that, on average, the nearest HZ planet around G and K dwarfs is about 6 pc away, and there are about 4 HZ rocky planets around G and K dwarfs within 10 pc of the Sun."

*(phys.org discusses this paper **here**)*

SARA SEAGER EXPLAINED THE “PEDAL POWER” PROPOSAL FOR GETTING MUCH BETTER DATA ON EXO PLANETS, ESPECIALLY EARTH-SIZED PLANETS



EVEN JUST 10 LIGHT YEARS AWAY, AMONG THE NEAREST OF ALL STARS, AN EARTH LIKE PLANET IN THE HABITABLE ZONE WOULD BE SO DIM IT WOULD BE LIKE THE VERY FAINTEST GALAXIES EVERY SEEN BY THE HUBBLE SPACE TELESCOPE. SO – BLOCK OUT COMPETITIVE LIGHT FROM PARENT STAR WITH “FLOWER PEDAL” OCCULTATION



PEDALS NEEDED IN ORDER TO MAXIMIZE DESTRUCTIVE DIFFRACTION WAVE INTERFERENCE AND MAXIMIZE BLOCKING OF LIGHT. A SIMPLE “DOT” WON’T DO THAT.

STAR SHADE NEEDS TO BLOCK THE LIGHT DOWN TO ***ONE TEN BILLIONTH OF NORMAL***. MUST MOVE PEDAL TO TENS OF THOUSANDS OF KILOMETERS AWAY FROM THE SPACECRAFT TO NOT BLOCK THE DESIRED PLANETS.