EXOPLANET SCIENCE IN REFLECTED LIGHT WITH EXTREME AO!

HOW WE'RE PUSHING THE FRONTIER OF EXOPLANET DETECTION AND CHARACTERIZATION

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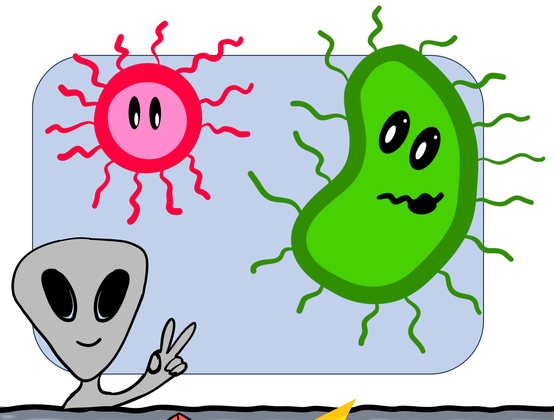
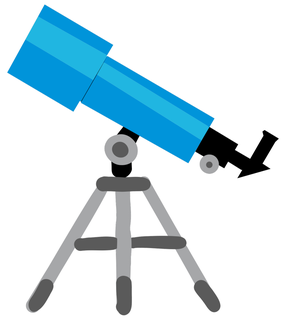
THE SEARCH FOR ***BIOSIGNATURES*** -- THE IMPRINT OF LIFE ON OBSERVABLE FEATURES OF EXOPLANETS -- IS ONE OF THE TOP SCIENTIFIC PRIORITIES IN EXOPLANET SCIENCE

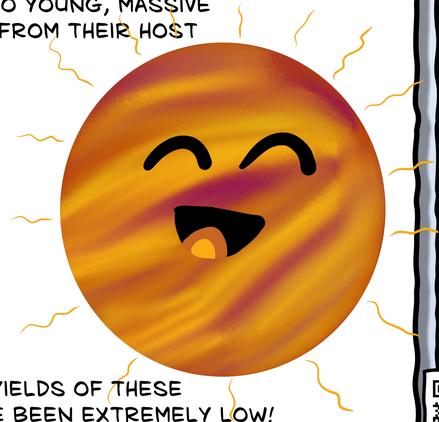


DIRECT IMAGING OF EXOPLANETS INVOLVES DETECTING THE PLANET DIRECTLY RATHER THAN INFERRING THE PRESENCE OF A PLANET THROUGH INDIRECT INDICATIONS

IT ENABLES DIRECT CHARACTERIZATION OF THE PLANET'S ATMOSPHERE, IMPORTANT FOR SEARCHING FOR SIGNS OF LIFE!

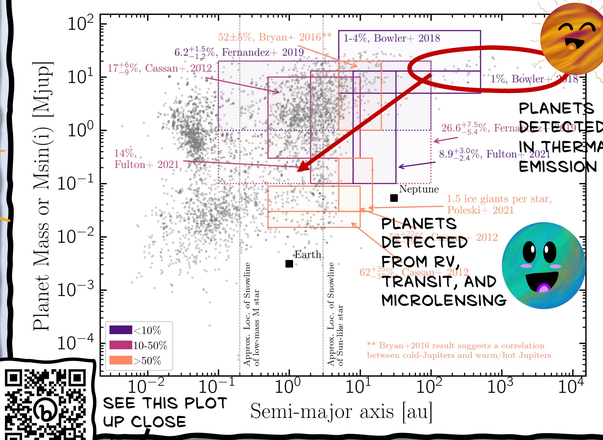


DIRECT IMAGING CURRENTLY LIMITED TO DETECTING PLANETS IN ***THERMAL EMISSION*** WHICH LIMITS DETECTIONS TO YOUNG, MASSIVE PLANETS FAR FROM THEIR HOST STAR.



BUT SURVEY YIELDS OF THESE PLANETS HAVE BEEN EXTREMELY LOW!

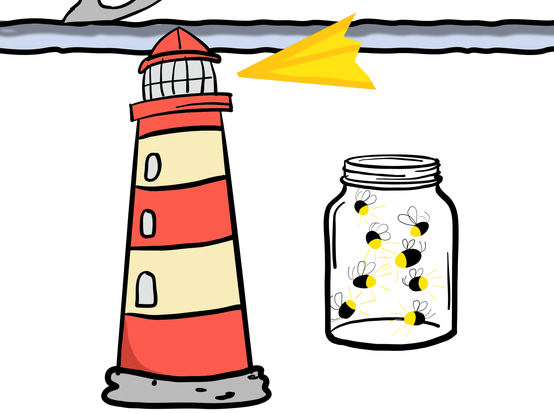
HOWEVER, WE KNOW THERE ARE ***TONS*** OF PLANETS THAT ARE SMALLER AND CLOSER (AND OLDER). TO DIRECTLY DETECT THEM, WE NEED TO LOOK AT ***THE LIGHT THEY REFLECT*** FROM THEIR HOST STAR



PLANETS DETECTED IN THERMAL EMISSION

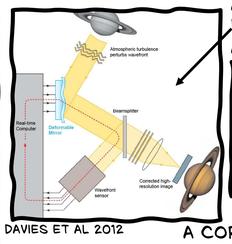
PLANETS DETECTED FROM RV, TRANSIT, AND MICROLENSING

SEE THIS PLOT UP CLOSE



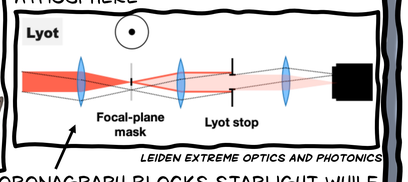
BUT THIS IS ***REALLY HARD***! FOR EXAMPLE, TO DETECT PROXIMA CENTAURI B (THE NEAREST KNOWN PLANET) IN REFLECTED LIGHT, WE NEED TO BE ABLE TO DETECT SOMETHING 10 MILLION TIMES FAINTER THAN THE STAR, THE EQUIVALENT OF TRYING TO SEE A JAR OF FIREFLIES NEXT TO A LIGHTHOUSE LIGHT!

WE CAN ACHIEVE HIGH CONTRASTS LIKE THIS THROUGH A COMBINATION OF ADAPTIVE OPTICS, CORONAGRAPHY, AND POST-PROCESSING



DAVIES ET AL 2012

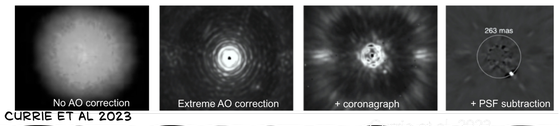
ADAPTIVE OPTICS CORRECTS DISTORTION CAUSED BY THE ATMOSPHERE



LEIDEN EXTREME OPTICS AND PHOTONICS

A CORONAGRAPH BLOCKS STARLIGHT WHILE LETTING PLANET LIGHT PASS THROUGH

POST-PROCESSING USES MATH TO SUBTRACT RESIDUAL STARLIGHT WITHOUT SUBTRACTING PLANET LIGHT

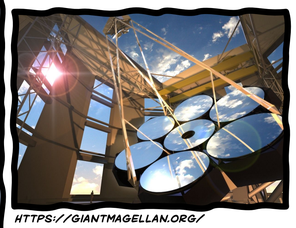


CURRIE ET AL 2023

EXAO IS HERE TO SAVE THE DAY!

MAGAO-X IS OUR ***EXTREME ADAPTIVE OPTICS*** INSTRUMENT BUILT TO IMAGE THE FIRST EXOPLANETS IN REFLECTED LIGHT! IT GOES ON THE MAGELLAN TELESCOPE IN CHILE

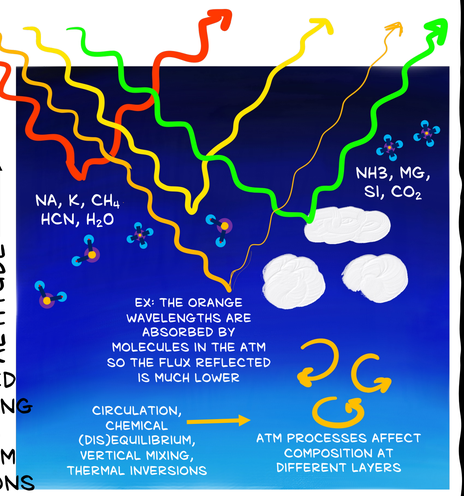
MORE ABOUT MAGAO-X



HTTPS://GIANTMAGELLAN.ORG/

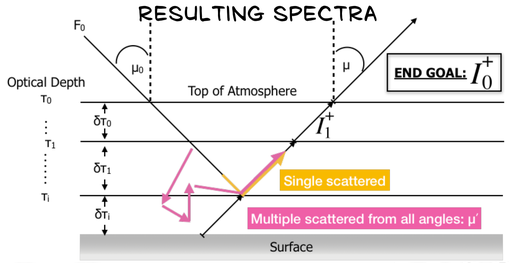
WE ARE ALSO BUILDING GMAGAO-X FOR THE GIANT MAGELLAN TELESCOPE (A 25.4 METER TELESCOPE BEING BUILT IN CHILE) TO IMAGE HUNDREDS OF PLANETS IN REFLECTED LIGHT!

LIGHT OF DIFFERENT WAVELENGTHS INTERACT WITH THE ATM IN DIFFERENT WAYS, PRODUCING A REFLECTANCE SPECTRUM WITH FEATURES IMPRINTED FROM THE ABSORPTION FEATURES OF THE ATOMS/MOLECULES IN THE ATM.



REFLECTED LIGHT IMAGING LETS US PROBE ATM COMPOSITIONS

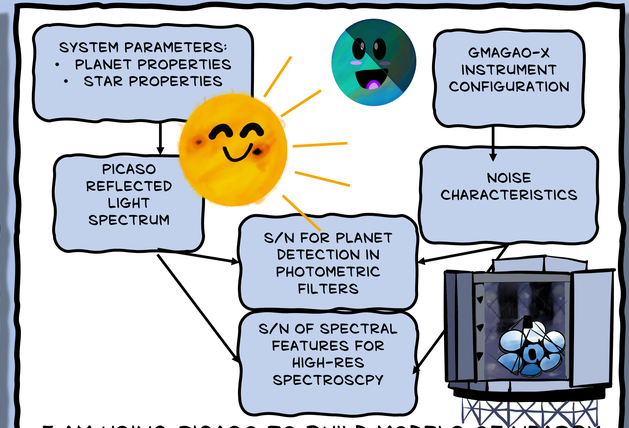
PICASO IS AN OPEN-SOURCE PYTHON CODE FOR CREATING SELF-CONSISTENT 1-D EXOPLANET ATMOSPHERE MODELS INCORPORATING ALL THE PHYSICS FROM SYSTEM PARAMETERS THROUGH TO RESULTING SPECTRA



PICASO DOCUMENTATION

THE PHYSICS BEHIND PICASO

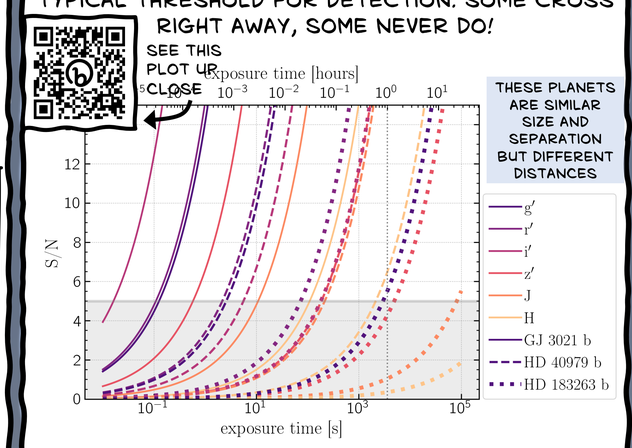
PICASO



I AM USING PICASO TO BUILD MODELS OF NEARBY KNOWN EXOPLANETS AND COMBINE THEM WITH A GMAGAO-X NOISE MODEL TO PREDICT OBSERVATIONS AND OBSERVABLE SPECTRAL FEATURES

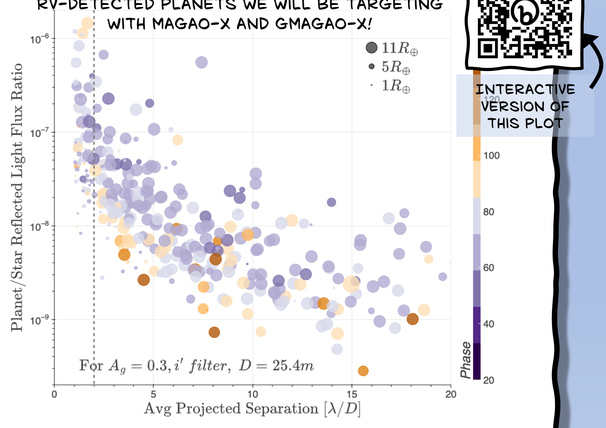
FOR EXAMPLE, THIS PLOT SHOWS SIGNAL-TO-NOISE RATIO FOR 3 GAS GIANTS IN 5 GMAGAO-X FILTERS OVER TIME. THE GREY MARKS S/N=5, A TYPICAL THRESHOLD FOR DETECTION. SOME CROSS RIGHT AWAY, SOME NEVER DO!

SEE THIS PLOT UP CLOSE



THIS WORK IS VITAL FOR PLANNING FOR THE NEXT GENERATION OF PLANET DETECTION AND CHARACTERIZATION!

THIS PLOT SHOWS ~300 OF THE NEAREST KNOWN RV-DETECTED PLANETS WE WILL BE TARGETING WITH MAGAO-X AND GMAGAO-X!



INTERACTIVE VERSION OF THIS PLOT

LOGAN PEARCE IS 5TH YEAR PHD STUDENT AT UNIVERSITY OF ARIZONA. IN ADDITION TO THIS WORK, SHE IS PI OF TWO SCIENCE SURVEYS WITH MAGAO-X, YOU SHOULD ASK HER ABOUT THOSE! SHE IS A NAVY VET AND CALLS AUSTIN TX HOME. SHE LIVES IN TUCSON WITH HER 4YO LAB LANI. SCAN THE QR CODE FOR MORE!

ALL IMAGES, PLOTS, AND DRAWINGS ARE MINE EXCEPT WHERE NOTED.

THIS WORK WAS CONDUCTED AT NASA AMES RESEARCH CENTER AND WITH SUPPORT FROM THE NSF INTERN PROGRAM NSF 21-013

THERE'S TONS MORE ON MY WEBSITE!