

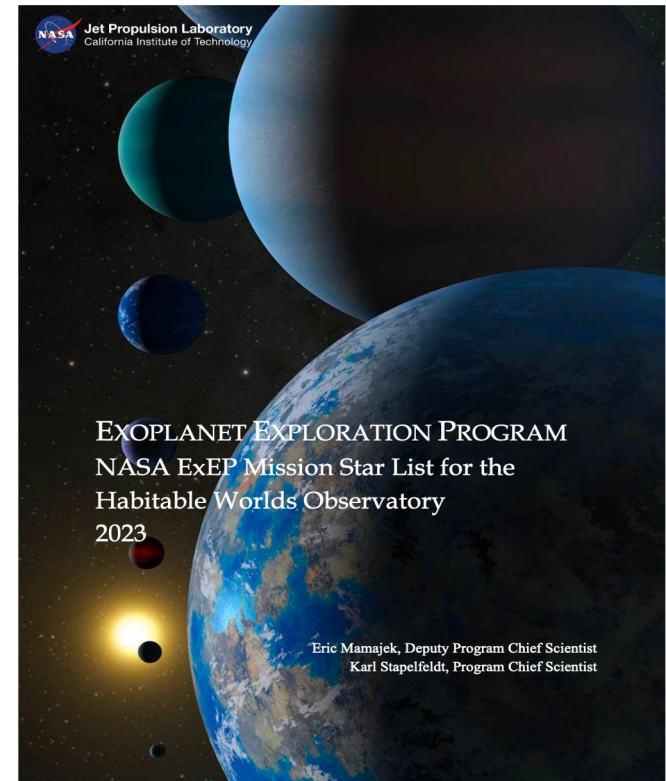


Input Star Catalogs

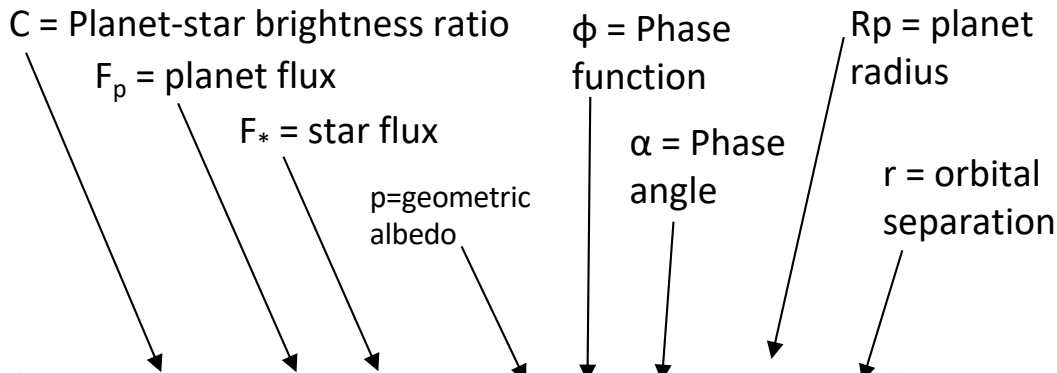
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Exoplanet Yield Modeling Workshop
242nd AAS Meeting, Albuquerque
June 8, 2023



What stellar parameters do yield modelers care about?



$$C = F_p / F_* = p \phi(\alpha) (R_p / r)^2$$

$$\phi(\alpha) = (\sin \alpha + (\pi - \alpha) \cos \alpha) / \pi$$

$$\Delta \text{mag} = -2.5 \log F_p / F_* = -2.5 \log C$$

$$\text{mag}_p = \text{mag}_* + \Delta \text{mag}$$

Planet apparent
magnitude

Star apparent
magnitude

Key questions:

- How *bright* will hypothetical exoplanet be?
- What is the *planet-star brightness ratio*?
- At what *angular separation* is the exoplanet from the star?

Key stellar parameters:

- *Brightness* of star in some band
- *Luminosity* of star (to predict habitable zone and/or Earth-equivalent Instellation Distance (EEID))
- *Distance* to star & exoplanet

(see review by Traub & Oppenheimer 2010 in *Exoplanets*)

Input Catalogs and Resources



Large star catalogs	Hipparcos Gaia DR3 TIC, WDS, SB9
Online access to star catalogs & electronic tables	SIMBAD, Vizier MAST NASA Exoplanet Archive
Star catalogs compiled for exoplanet yield calculations	ExoCAT (2015) ExEP HWO Star List (2023) Tuchow & Stark (in prep.)

Raw Sources of Stellar Data: Input Star Catalogs



- Getting familiar with star catalogs: SIMBAD and VizieR
 - **SIMBAD** astronomical database provides basic data, cross-IDs, bibliography and measurements for astronomical objects outside the solar system: <http://simbad.cds.unistra.fr/simbad/>
 - **VizieR** allows you to query electronic tables (e.g., star catalogs, tables from journal articles) by celestial position or a SIMBAD-resolvable designation (e.g., “HD 172167”, “HR 7001”, “GJ 721”, “Vega”, “alf Lyr”): <https://vizier.cds.unistra.fr/viz-bin/VizieR>
- Generally, the brighter the star, the better studied it is, and the more catalogs and electronic tables it appears in.
- ALL star catalogs have limitations and issues to be aware of
- **NO single star catalog has it all**

SIMBAD entry for a star

(in this case for
a very bright,
famous star)

<http://simbad.cds.unistra.fr/simbad/sim-id?Ident=Vega>

other query modes:

Identifier query
Coordinate query
Criteria query
Reference query
Basic query
Script submission
TAP
Output options
Help

Query : Vega

Basic data :

*** alf Lyr -- delta Sct Variable**

Other object types: * (*,AG,...),** (ADS,CCDM,...),PM* (LSPM,LTT,...),V* (CSV,NSV,...),UV (CEL,EUVE,...),IR (IRAS,IRC,...),smm (JCHTSE,JCHTSF),MIR (AKARI,WISE),dS* (2003AsTL),X (1E),MIR (2MASS)

ICRS coord. (ep=J2000) : 18 36 56.33635 +38 47 01.2802 (Optical) [3.51 2.81 90] A 2007A6A...474..653V

FK4 coord. (ep=B1950 eq=1950) : 18 35 14.66713 +38 44 09.8049 [3.51 2.81 90]

Gal coord. (ep=J2000) : 067.44820813 +19.23725227 [3.51 2.81 90]

Proper motions mas/yr : 200.94 286.23 [0.32 0.40 0] A 2007A6A...474..653V


Radial velocity / Redshift / cz : V(km/s) -20.60 [0.21] / z(-) -0.000069 [0.000001] / cz -20.60 [0.20] A 2006A11...32..759G

Parallax (mas) : 130.23 [0.36] A 2007A6A...474..653V

Spectral type : ANva C 2003A2...126.20486

Fluxes (J) : U 0.03 [-] C 2002yCat.2237...00
B 0.03 [-] C 2002yCat.2237...00
V 0.03 [-] C 2002yCat.2237...00
R 0.07 [-] C 2002yCat.2237...00
I 0.10 [-] C 2002yCat.2237...00
J -0.177 [0.206] D 2003yCat.2246...0C
H -0.829 [0.146] D 2003yCat.2246...0C
K 0.129 [0.106] D 2003yCat.2246...0C

SIMBAD Query around within 2 arcmin



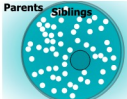
All CDS (CDSPortal)

Send to

Photometry within 5 arcsec

Hierarchy : number of linked objects
whatever the membership probability is (see description here) :

parents : 1 siblings : 61 Display criteria : All



Identifiers (63) :

An access of full data is available using the icon Vizier near the identifier of the catalogue

<ul style="list-style-type: none"> + alf Lyr + 3 Lyr ADS 11510 A AG+38 1711 AKARI-IRC-V1 J1836564+384703 ASCC 507896 BD+38 3238 CDM 118369+3847A CEL 4636 CSI+38 3238 1 CSV 101745 1E 183515+3844.3 EUVE 11836+38.7 PKS 699 GAT 1265 GC 25466 	<ul style="list-style-type: none"> GRV 11885 GENP +1.00172167 GJ 721 GJ 721.4 HD 172167 HGM 706 HIC 91262 HIP 91262 HR 7001 IDS 18336+3841 A IRAS 18352+3844 IRAS F18352+3844 IRC +40322 JCHTSE J183656.4+384709 JCHTSF J183656.4+384709 JPL1 2999 	<ul style="list-style-type: none"> LSPM J1836+3847 LTT 15486 2MASS J18365633+3847012 N30 4138 NAME Vega NLTT 46746 NSV 11128 Rpc 128.93 PLX 4293 PLX 4293.00 PMC 90-93 496 PPM 81558 RAFGL 2208 ROT 2633 SAO 67174 SKYP 34103 	<ul style="list-style-type: none"> TD1 22883 TYC 157587146 TYC 3105-2078-1 UBV 15842 URV M 23118 USNO-B1.0 1287-00305764 USNO 882 uvby98 100172167 Ve alf Lyr WDS J18369+3846A WEB 15681 WISE J183656.49+384703.9 Zah 277 [WFB3] 1223 EQ 183456.7+384615.4
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References (2640 between 1850 and 2023) (Total 2640)

Simbad bibliographic survey began in 1850 for stars (at least bright stars) and in 1983 for all other objects (outside the solar system).

Follow new references on this object

Reference summaries :

from: 1850 to: \$currentYear

or select by: (not exhaustive, explanation here)

Collections of Measurements

velocities : 20 diameter : 2 ROT : 8 Fe_H : 51 PLX : 4 PM : 6 MK : 35

VizieR



Query
electronic
tables around
a position or
SIMBAD-
resolvable
name

VizieR

[VizieR home](#) · [Photometry viewer](#) · [Query VizieR using TAP](#) · [X-match tables](#) · [Query images/spectra](#)

The VizieR service is now hosted by CDS domain (cds.unistra.fr). Please, modify your configuration for the new domain.

Find catalogs among 23667 available

Clear Find...

Expand search

Wavelength | **Mission** | **Astronomy**

Radio	AKARI	Abundances
Millimeter	ANS	Ages
IR	ASCA	AGN
optical	BeppoSAX	Associations
UV	Cassini-Huygens	Asteroseismology
EUV	CGRO	Atomic_Data
X-ray	Chandra	Binaries:cataclysmic

Search by Position across 26339 tables

Target Name (resolved by [Sesame](#)) or Position: J2000 Target dimension: 2 arcmin Go!

NB: The epoch used for the query is the original epoch of the table(s) Radius Box size

[More about VizieR](#)

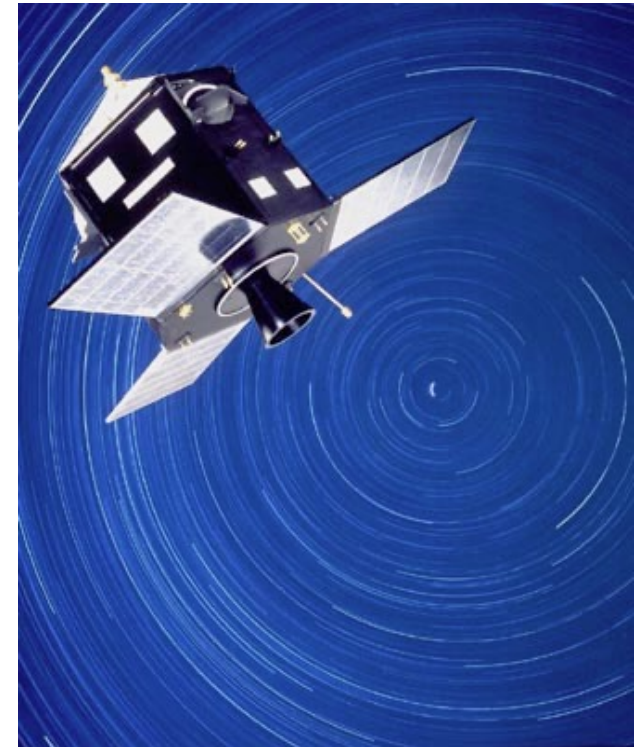
Tools related to VizieR

- [Catalogue collection](#) : Search VizieR catalogues available via various services (FTP, VizieR, TAP, ...)
- [CDS Portal](#) : Access CDS data including VizieR, Simbad and Aladin using the CDS portal
- [Spectra, images in VizieR](#) : Search Spectra, images in VizieR
- [Photometry viewer](#) : Plot photometry (sed) including all VizieR
- [TAP VizieR](#) : query VizieR using ADQL (a SQL extension dedicated for astronomy)
- [CDS cross-match service](#) : fast cross-identification between any 2 tables, including VizieR catalogues, SIMBAD

Hipparcos & Tycho



- **Hipparcos** was an ESA space astrometry mission; observed stars all over sky between 1989-1993.
- **Hipparcos (HIP)** catalog of positions, proper motions, parallaxes, photometry (measured Tycho B_T, V_T system => BV Johnson), astrometry for 118,218 *pre-selected* stars published 1997. Parallaxes ~ 1 mas accuracy (Perryman+1997, ESA 1997).
- **Tycho (TYC)** catalog of \sim million stars (1997), reanalyzed and connected to recalibrated century-old positions => improved proper motions (TYC-2, 2000)
- “HIP2” reanalysis by van Leeuwen (2007)
- Completeness *varies over sky*: $V \sim 7.3-9.0$ mag
- Formed basis for numerous surveys the past ~ 25 yrs



(ESA,
<https://www.cosmos.esa.int/web/hipparcos>)

Gaia



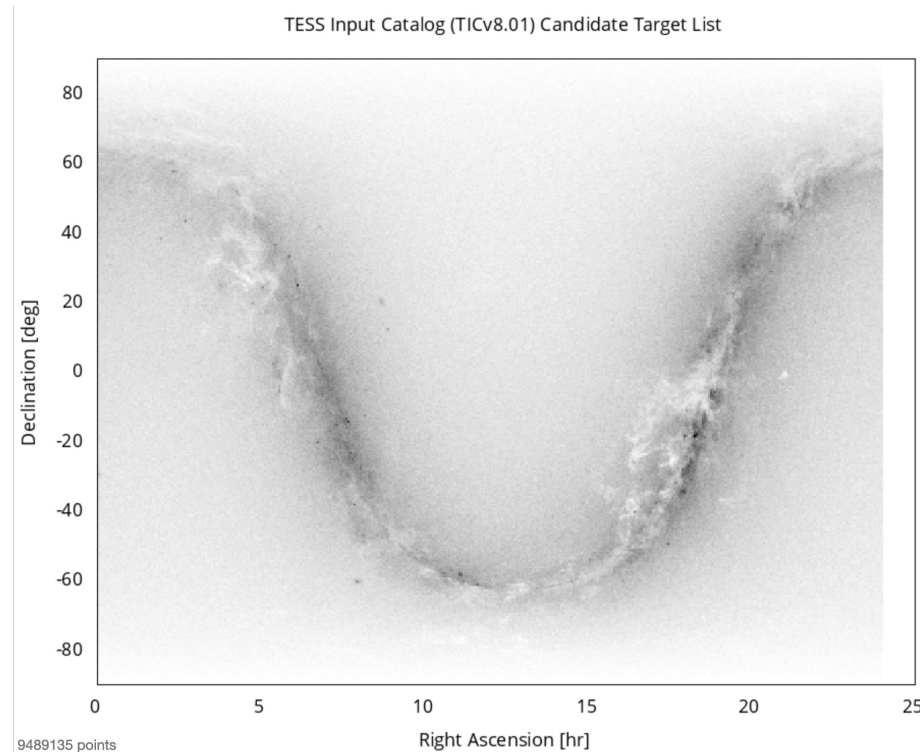
- ESA *Gaia* mission launched December 2013
- Measured positions, proper motions, parallaxes, photometry for nearly 2 billion objects (including spectra, radial velocities, variability analysis for millions of objects) – creating largest, most precise 3D map of the Milky Way!
- Multiple data releases: DR1(2016), DR2(2018), DR3(2022)
- Contents of Gaia DR3:
<https://www.cosmos.esa.int/web/gaia/dr3>
- Volume-limited catalogs:
 - **The Fifth Catalogue of Nearby Stars (CNS5)** – 5931 objects within 25 pc (Golovin+2023, <https://dc.gvo.org/CNS5>) – update to “Gliese-Jahreiss (GJ) catalog”
 - **The Gaia Catalogue of Nearby Stars** – 331,312 objects within 100 pc (Gaia Collaboration, Smart+2021, <http://cdsarc.u-strasbg.fr/viz-bin/cat/J/A+A/649/A6>)



Credit: ESA/ATG medialab; background: ESO/S. Brunier

TIC: TESS Input Catalog

- Compiled catalog of stellar parameters for 1.5 billion sources
- TIC v7 based on 2MASS, TIC v8 based on Gaia DR2
- Matched to 2MASS, UCAC4, APASS, SDSS, WISE. Estimated stellar parameters!
- Includes magnitudes in B,V,G,u, g,r,i,z,J,H,Ks,W1,W2,W3,W4
- <https://tess.mit.edu/science/tess-input-catalogue/>
- Stassun, Oelkers, Paegert+ 2019 (v8.0)
- Binaries & artefacts are an issue for 1% of sources (see Paegert+ 2021 v8.2 update arXiv:2108.04778)



Binaries

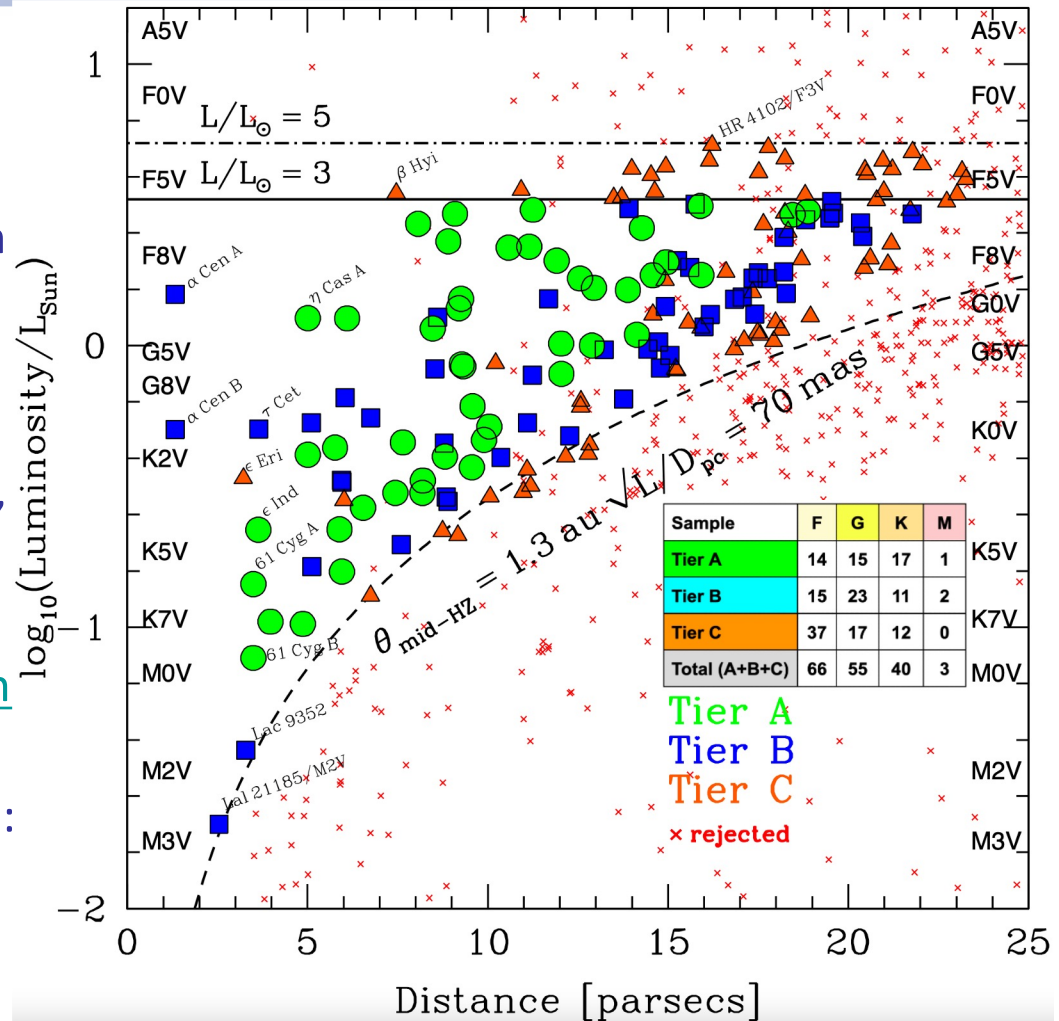


- **Stellar multiples** are the bane of all star cataloguing efforts (and a source of bane for starlight suppression techniques to image exoplanets!)
- **Washington Double Star (WDS) Catalog** (Mason+2001)
 - Contains resolved companions (imaging, speckle, AO, occultation)
 - Contains mix of physical companions and ‘interlopers’
 - Regularly updated: <http://www.astro.gsu.edu/wds/>
- **9th Catalogue of Spectroscopic Binary Orbits (SB9)** (Pourbaix+2004)
 - Was regularly updated through 2011 <https://sb9.astro.ulb.ac.be/>
- **Gaia** catalogs include some new companions, even for relatively nearby, bright stars at tens of pc! (see Kervella+2022)

ExEP Mission Stars List for HWO (2023)



- NASA ExEP scientists Eric Mamajek & Karl Stapelfeldt presented an initial HWO target star list in January 2023 to motivate precursor science activities on stars most amenable to imaging exoEarths w/ a 6-m space telescope
- 164 stars in 3 tiers. Tiers factored in planet-star ratios of exoEarths, binarity, disks. ~50 data columns.
- Documentation & Seminar Slides: <https://exoplanets.nasa.gov/exep/science-overview/>
- Online table at NASA Exoplanet Archive: https://exoplanetarchive.ipac.caltech.edu/cgi-bin/TblView/nph-tblView?app=ExoTbIs&config=DI_STARS_EXEP



Acknowledgements



Thanks to the NASA Exoplanet Exploration Program for support.

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology under contract with the National Aeronautics and Space Administration.
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