



Studying Space

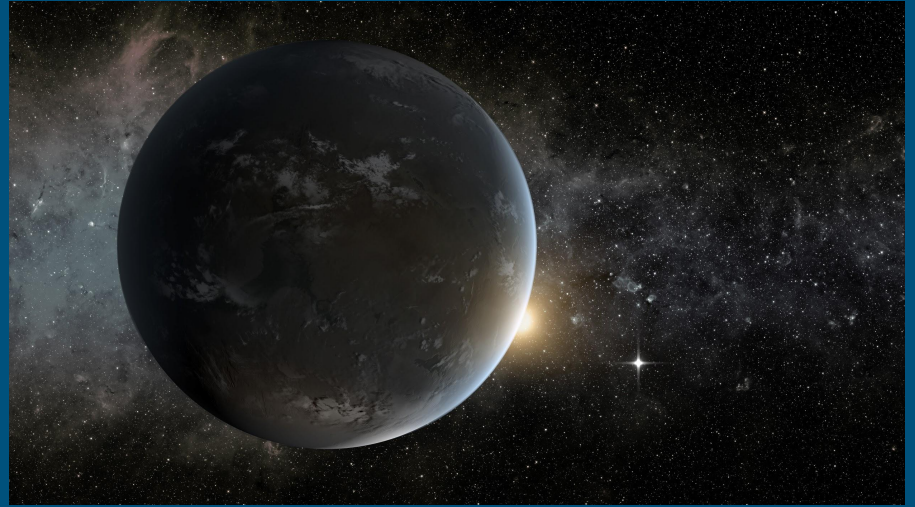
(and Relational Databases)

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Presentation Outline

- Getting Data
- Creating PSQL Tables
- Wondering About Space



Data Source: NASA Exoplanet Archive



NASA EXOPLANET ARCHIVE
A SERVICE OF NASA EXOPLANET SCIENCE INSTITUTE



[Home](#) [About the Archive](#) [Data](#) [Tools](#) [User Guides & Help Desk](#)

1,911 Confirmed Planets 11/19/2015 →

477 Multi-Planet Systems 11/19/2015 →

4,696 Kepler Candidates 09/18/2015 →

[View more Planet and Candidate statistics](#) →

Explore the Archive

Name or Coordinates [Search](#)

Optional Radius (arcsec) [Advanced Search](#) →

Transit Surveys 21,665,058 Light Curves

Kepler

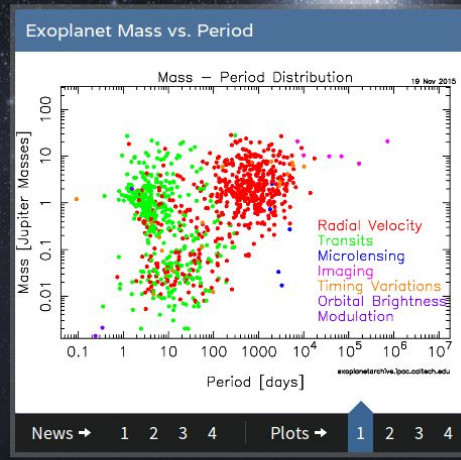
The first space mission to search for Earth-sized and smaller planets in the habitable zone of other stars in our neighborhood of the galaxy.

[Light Curves](#) → [Objects of Interest \(KOI\)](#) →

[Threshold-Crossing Events](#) → [Search Stellar Data](#) →

[Completeness and Reliability Products](#) → [Documentation](#) →

[Kepler](#) [KFLT](#) [SuperWASP](#) [More Data Sets](#)



Tools & Services

[Periodogram](#) → [Predicted Observables for Exoplanets Service](#) →

[Transit and Ephemeris Service](#) → [Build a Query \(API\)](#) →

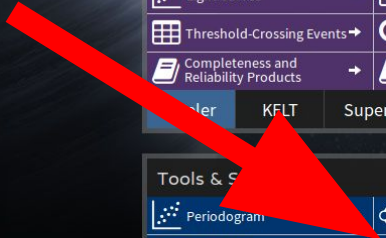
[Search Interactive Tables](#) → [Search Extended Planet Data](#) →

Work with Data

[Confirmed Planets Plotting Tool](#) → [Confirmed Planets Table](#) →

[Search K2 Targets](#) → [Bulk Download Service](#) →

[Transit Spectroscopy](#) → [Kepler CFOP](#) →



wget the data



```
// get exoplanet data as txt with column descriptions
wget "http://exoplanetarchive.ipac.caltech.edu/cgi-bin/nstEDAPI/nph-
nstEDAPI?table=exoplanets&select=pl_hostname,pl_discmethod,pl_pnum,
pl_name,pl_eqt,pl_trandep,pl_trandur,pl_ratror,pl_orbper,pl_masse,
pl_rade,ra,dec,pl_facility,pl_telescope,pl_status,pl_disc,pl_locale,
pl_mnum,pl_pelink,pl_edelink,st_rah,st_plx,st_pm,st_radv,st_spstr,
st_logg,st_lum,st_dens,st_age,st_vsini,&order=dec&format=ascii" -O
"planets.txt"
```

```
// get exoplanet data as csv
...repeat wget with format as csv instead of ascii
```

Data Source: NinePlanets.org

Name	Radius (km)	Mass (kg)	Dens	Abo	Vo	Rotate (days)	Dimensions (km)
Sun	695000	1.99e30	1.41	?	-26.	24.6	
Mercury	2440	3.30e23	5.43	.11	-1.9	58.6	
Venus	6052	4.87e24	5.24	.65	-4.4	-243	
Earth	6378	5.97e24	5.52	.30	-	0.99	
Mars	3397	6.42e23	3.93	.15	-2.0	1.03	
Jupiter	71492	1.90e27	1.33	.52	-2.7	0.41	
Saturn	60268	5.68e26	0.69	.47	0.7	0.45	
Uranus	25559	8.68e25	1.32	.51	5.5	-0.72	
Neptune	24766	1.02e26	1.64	.41	7.8	0.67	
Pluto	1150	1.27e22	2.06	.55	13.6	-6.39	(z)

Data Tables Created

- Exoplanets
- Stars
- Endoplanets
- Telescopes
- Facilities

```
\COPY temp_exoplanets  
FROM 'data/exoplanets.  
csv' DELIMITER ',' CSV  
HEADER;
```

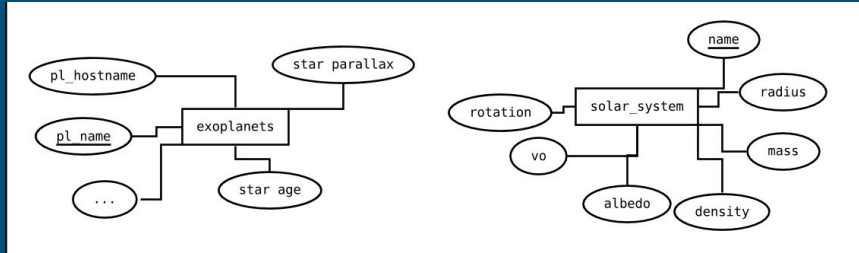
```

CREATE TABLE temp_exoplanets (
  pl_hostname TEXT, /* Planet Host Star Name */
  pl_discmethod TEXT, /* Method of Discovery */
  pl_pnum INTEGER, /* Number of Planets in System */
  pl_name VARCHAR(30), /* Planet Common Name */
  pl_eqt INTEGER, /* Planet Equilibrium Temperature Value [K] */
  pl_trandep DECIMAL, /* Planet Transit Depth Value [percentage] */
  pl_trandur DECIMAL, /* Planet Transit Duration Value [days] */
  pl_rator DECIMAL, /* Ratio of Planet to Stellar Radius Value */
  pl_orbper DECIMAL, /* Planet Orbital Period [Days] */
  pl_masse DECIMAL, /* Planet Mass Value [Earth mass] */
  pl_rade DECIMAL, /* Planet Radius Value [Earth radii] */
  ra DECIMAL, /* ra [degrees] */
  dec DECIMAL, /* Dec Value [degrees] */
  pl_facility TEXT, /* Discovery Facility */
  pl_telescope TEXT, /* Discovery Telescope */
  pl_status INTEGER, /* Status (1 = announced, 2 = submitted, 3 = accepted, 0 = retracted) */
  pl_disc INTEGER, /* Year of Discovery */
  pl_locale TEXT, /* Discovery Locale */
  pl_mnum INTEGER, /* Number of Moon around Planet */
  pl_pelink TEXT, /* Link to Extrasolar Planets Encyclopaedia Web Site */
  pl_edelink TEXT, /* Link to Exoplanet Data Explorer Web Site */
  st_rah DECIMAL, /* RA Value [decimal hrs] */
  st_plx DECIMAL, /* Parallax Value [mas] */
  st_pm DECIMAL, /* Stellar Total Proper Motion Value [mas/yr] */
  st_radv DECIMAL, /* Stellar Radial Velocity Value [km/s] */
  st_spstr TEXT, /* Stellar Spectral Type Value */
  st_logg DECIMAL, /* Stellar Surface Gravity Value [log10(cm/s**2)] */
  st_lum DECIMAL, /* Stellar Luminosity Value [log(Solar)] */
  st_dens DECIMAL, /* Stellar Density Value [g/cm**3] */
  st_age DECIMAL, /* Stellar Age Value [Gyr] */
  st_vsini DECIMAL /* Stellar Vsin i Value [km/s] */
);
\COPY temp_exoplanets FROM 'data/exoplanets.csv' DELIMITER ',' CSV HEADER;

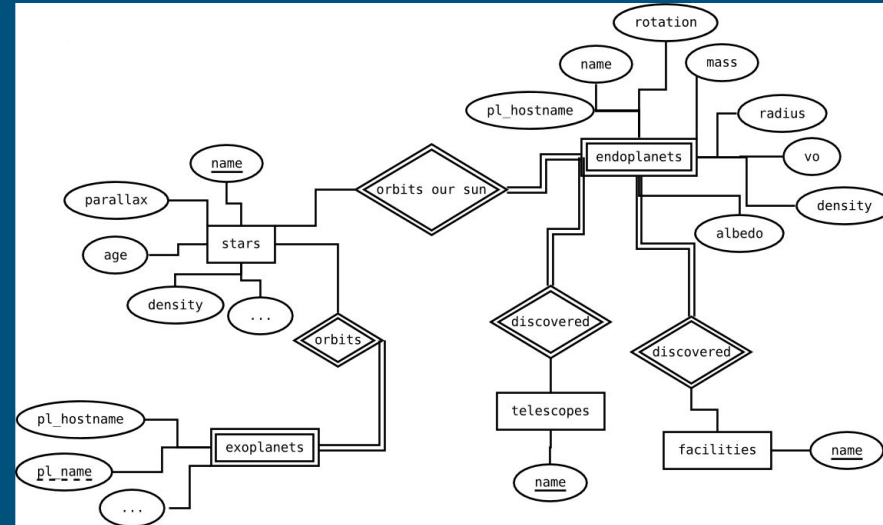
```

Entity Relationship Diagrams (ERDs)

Original Data Format



Normalized Data Format



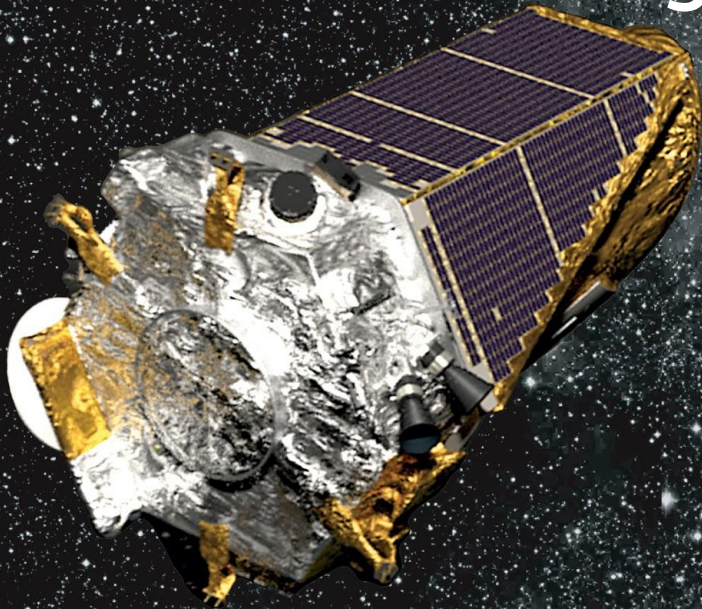
Normalizing the Temporary Tables

```
CREATE TABLE stars (  
    name TEXT,  
    st_rah DECIMAL, /* RA Value [decimal hrs] */  
    st_plx DECIMAL, /* Parallax Value [mas] */  
    st_pm DECIMAL, /* Total Proper Motion [mas/yr] */  
    st_radv DECIMAL, /* Stellar Radial Velocity [km/s] */  
    st_spstr TEXT, /* Stellar Spectral Type */  
    st_logg DECIMAL, /* Surface Gravity [log10(cm/s**2)] */  
    st_lum DECIMAL, /* Luminosity Value [log(Solar)] */  
    st_dens DECIMAL, /* Stellar Density Value [g/cm**3] */  
    st_age DECIMAL, /* Stellar Age Value [Gyr] */  
    st_vsini DECIMAL /* Stellar Vsin i Value [km/s] */  
);
```

```
INSERT INTO stars (SELECT DISTINCT  
    pl_hostname,  
    st_rah,  
    st_plx,  
    st_pm,  
    st_radv,  
    st_spstr,  
    st_logg,  
    st_lum,  
    st_dens,  
    st_age,  
    st_vsini  
    FROM temp_exoplanets);  
INSERT INTO stars (name, st_dens) VALUES ('Sun',1.41);
```

Wondering About Space

Analyzing the
Data



What is like our Sun?

```
SELECT name, st_rah,  
st_logg, st_dens, st_age  
FROM stars  
WHERE st_spstr='G2';
```

Spectral Type: G2

name	st_rah	st_logg	st_dens	st_age
CoRoT-27	18.56638753	4.40	1.2400	4.210
Kepler-452	19.73357920	4.32	0.8400	6.000
WASP-95	22.49714593	4.38	1.1000	2.400
Sun		4.44	1.41	4.6

(4 rows)

More General Search

```
SELECT name, st_rah, st_logg,  
st_dens, st_age, st_spstr
```

```
FROM stars
```

```
WHERE st_spstr LIKE '%G2%';
```

name	st_rah	st_logg	st_dens	st_age	st_spstr
CoRoT-27	18.56638753	4.40	1.2400	4.210	G2
CoRoT-17	18.57995027	4.40	0.3200	10.700	G2 V
16 Cyg B	19.69777018	4.36			G2.5 V
HD 81040	9.39641317	4.50		0.730	G2/G3
51 Peg	22.95777181	4.33		4.000	G2.5 IV
HD 208487	21.95551351	4.33			G2 V
HD 82943	9.58075968	4.46			G2/3 V
Kepler-452	19.73357920	4.32	0.8400	6.000	G2
CoRoT-20	6.51469387	4.20	1.5100	0.100	G2 V
HD 68988	8.30615896	4.41			G2 V
OGLE-TR-10	17.85784722				G2 V
HD 224693	23.99828695	4.38			G2 IV
HD 2039	0.40563272	4.38			G2/G3 IV/V
WASP-95	22.49714593	4.38	1.1000	2.400	G2
HD 164595	18.01080322	4.44			G2 V
Kepler-41	19.63421527	4.47			G2 V
HD 86226	9.94162394	4.36		1.500	G2 V
HD 121504	13.95478821	4.64		1.200	G2 V
HD 216437	22.91096802				G2/3 IV
HD 141937	15.87154134				G2/3 V
HD 23127	3.65656637			7.100	G2 V
HD 564	0.16467274	4.53		5.500	G2/G3 V
KELT-8	18.88703400	4.08	0.3690	5.400	G2 V
HD 44219	6.33731181	4.21			G2 V
Kepler-17	19.89301827	4.53	1.4150	1.780	G2 V
HD 6434	1.07781970	4.60		3.800	G2/3 V
Kepler-427	19.21697200	4.14	0.4000	7.000	G2 V
Kepler-44	20.00682347	4.22	0.6300	5.800	G2 IV
HD 117618	13.54043172				G2 V
HD 222155	23.63341878	4.10		8.200	G2 V
HD 183263	19.47349243	4.40		8.130	G2 IV
WASP-58	18.31340427	4.27	0.8200	3.200	G2 V
Sun		4.44	1.41	4.6	G2

(33 rows)

How many (identified) planets do G2 stars host?

```
csci403=> SELECT stars.name, count(*)
FROM stars, exoplanets
WHERE st_spstr='G2' AND stars.
name=exoplanets.pl_hostname
GROUP BY stars.name;
```

name	count
WASP-95	1
Kepler-452	1
CoRoT-27	1

(3 rows)

```
csci403=> SELECT count(*) FROM endoplanets;
count
-----
          9
(1 row)
```

```
csci403=> DELETE FROM endoplanets WHERE
name LIKE '%Pluto%';
DELETE 1
```

```
csci403=> SELECT count(*) FROM endoplanets;
count
-----
          8
(1 row)
```

Finding Planets Seems Hard

```
csci403=> SELECT stars.name, count(*)
FROM stars, exoplanets
WHERE st_spstr LIKE '%G2%' AND stars.
name=exoplanets.pl_hostname
GROUP BY stars.name;
```

```
csci403=> SELECT AVG(sq.hosted_planets)
FROM (...above query... ) as sq;
```

```
      avg
-----
1.0625000000000000
(1 row)
```

name	count
HD 2039	1
HD 164595	1
HD 222155	1
Kepler-44	1
HD 216437	1
KELT-8	1
Kepler-41	1
HD 82943	2
Kepler-452	1
WASP-95	1
CoRoT-17	1
HD 81040	1
Kepler-17	1
HD 121504	1
HD 208487	1
WASP-58	1
HD 183263	2
HD 224693	1
HD 68988	1
HD 141937	1
CoRoT-20	1
Kepler-427	1
51 Peg	1
HD 86226	1
HD 44219	1
16 Cyg B	1
OGLE-TR-10	1
HD 23127	1
HD 117618	1
CoRoT-27	1
HD 6434	1
HD 564	1

(32 rows)

Which star hosts the most planets?

```
SELECT stars.name, count(*) as  
planets
```

```
FROM stars, exoplanets WHERE  
stars.name=exoplanets.  
pl_hostname
```

```
GROUP BY stars.name
```

```
ORDER BY planets DESC;
```

name	planets
KOI-351	7
HD 40307	6
Kepler-11	6
HD 10180	6
Kepler-169	5
Kepler-122	5
Kepler-102	5
Kepler-292	5
Kepler-20	5
GJ 667 C	5
Kepler-62	5
Kepler-55	5
Kepler-444	5
Kepler-186	5
55 Cnc	5
Kepler-296	5
Kepler-84	5
Kepler-32	5
Kepler-33	5
Kepler-238	5
HD 219134	4

How many exoplanets were discovered on Earth vs. in Space?

```
SELECT pl_locale, count(*)  
FROM exoplanets  
GROUP BY pl_locale;
```

```
pl_locale | count  
-----+-----  
Ground   |    809  
Space    |   1096  
  
(2 rows)
```


Which facilities have discovered the most planets?

```
SELECT pl_facility, count(*)  
as planets
```

```
FROM exoplanets, facility
```

```
WHERE facility.name =  
exoplanets.pl_facility
```

```
GROUP BY pl_facility
```

```
ORDER BY planets DESC;
```

pl_facility	planets
Kepler	1030
La Silla Observatory	176
W. M. Keck Observatory	133
SuperWASP	92
Multiple Observatories	58
HATNet	53
Anglo-Australian Telescope	33
Lick Observatory	31
CoRoT	29
K2	28
Haute-Provence Observatory	28
OGLE	28
McDonald Observatory	26
Okayama Astrophysical Observatory	18
Bohunsan Optical Astronomical Observatory	14
MOA	14
HATSouth	11
Las Campanas Observatory	11
Paranal Observatory	9
Thueringer Landessternwarte Tautenburg	8
Gemini Observatory	8
Subaru Telescope	8
XO	7
Hubble Space Telescope	6
KELT	6
Roque de los Muchachos Observatory	6
TrES	5
Fred Lawrence Whipple Observatory	5
Spitzer Space Telescope	3
Arecibo Observatory	3
Xinglong Station	2
United Kingdom Infrared Telescope	2
Cerro Tololo Inter-American Observatory	2
Palomar Observatory	2
Qatar	2
Infrared Survey Facility	1
MEarth Project	1
Kitt Peak National Observatory	1
Parkes Observatory	1
Yunnan Astronomical Observatory	1
Teide Observatory	1
Oak Ridge Observatory	1
Leoncito Astronomical Complex	1

(43 rows)

Planet Sizes (Max and Min Earth Radii)

```
csci403=> SELECT pl_name,  
pl_rade  
FROM exoplanets  
WHERE pl_rade=(  
SELECT MAX(pl_rade) FROM  
exoplanets);
```

pl_name	pl_rade
HD 100546 b	77.342

(1 row)

```
csci403=> SELECT pl_name,  
pl_rade  
FROM exoplanets  
WHERE pl_rade=(  
SELECT MIN(pl_rade) FROM  
exoplanets);
```

pl_name	pl_rade
Kepler-37 b	0.303

(1 row)