Exoplanet_period_radio_correlation

March 12, 2021

1 KEPLER Exoplanets Database

1.1 Observed exoplanet's periods VS. theoretical period calculated with stimated star mass and exoplanet mass.

Source: https://data.world/markmarkoh/kepler-confirmed-planets/workspace/project-summary?agentid=markmarkoh&datasetid=kepler-confirmed-planets NASA Exoplanet archive: https://exoplanetarchive.ipac.caltech.edu/docs/data.html

@Author: Javier Cebrián

@Attention: In this file there are Plotly (rendered with HTML) plots and equations. If you are viewing it with github, please enable external view with nbviewer

[1]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
import plotly.express as px
import plotly.graph_objects as go
import plotly.offline as pyo
import plotly.io as pio
pio.renderers.default = "notebook+pdf"

sns.set()
```

[2]:
```
planetsDf=pd.read_csv('../planets.csv',delimiter=',')
```

1.2 Correlation Obital Period [days] & Orbit Semi-Major Axis [AU]

Orbit Period and Semi-major Axis is related with the following equation: ##

$$T = 2\pi\sqrt{\frac{a^3}{\mu}}$$

Where a=semi-major axis , T=period and =MG with M=Mass of star and G=Gravity cte

$$T\ a^{3/2}$$

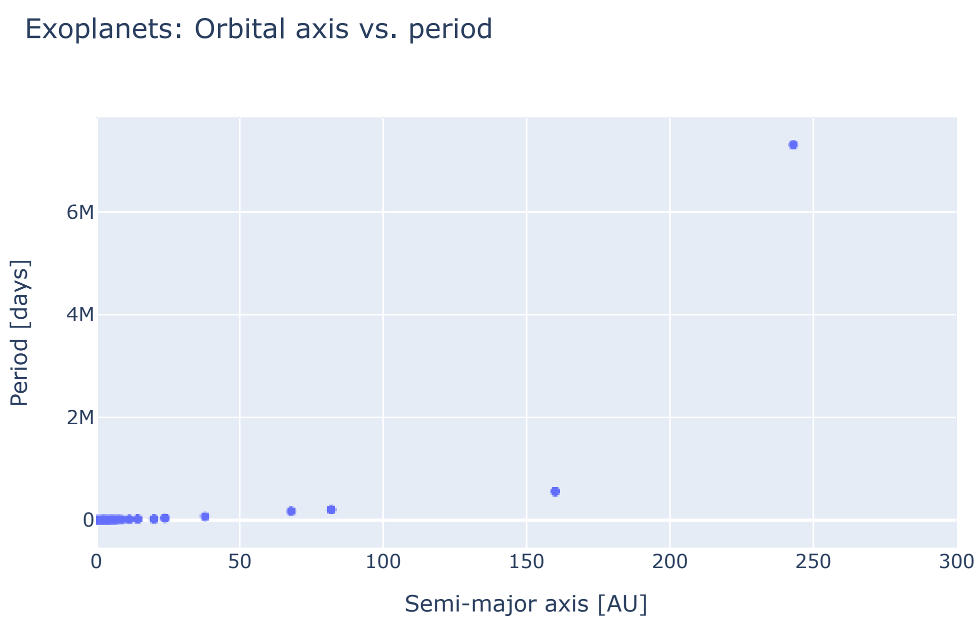
[3]:
```
planetsDf[['pl_orbsmax','pl_orbper']].corr()
```

[3]:

	pl_orbsmax	pl_orbper
pl_orbsmax	1.000000	0.815671
pl_orbper	0.815671	1.000000

Whith scatter representacion can be observed that correlation value is affected by Oph 11 exoplanet outlier.

[4]:
```
fig = px.scatter(x=planetsDf['pl_orbsmax'],␣
 ↪y=planetsDf['pl_orbper'],title="Exoplanets: Orbital axis vs.␣
 ↪period",width=800, height=320)
fig.update_xaxes(range=(0,300), title='Semi-major axis [AU]')
fig.update_yaxes(title='Period [days]')
fig.show()
```



Oph 11 is an outlier

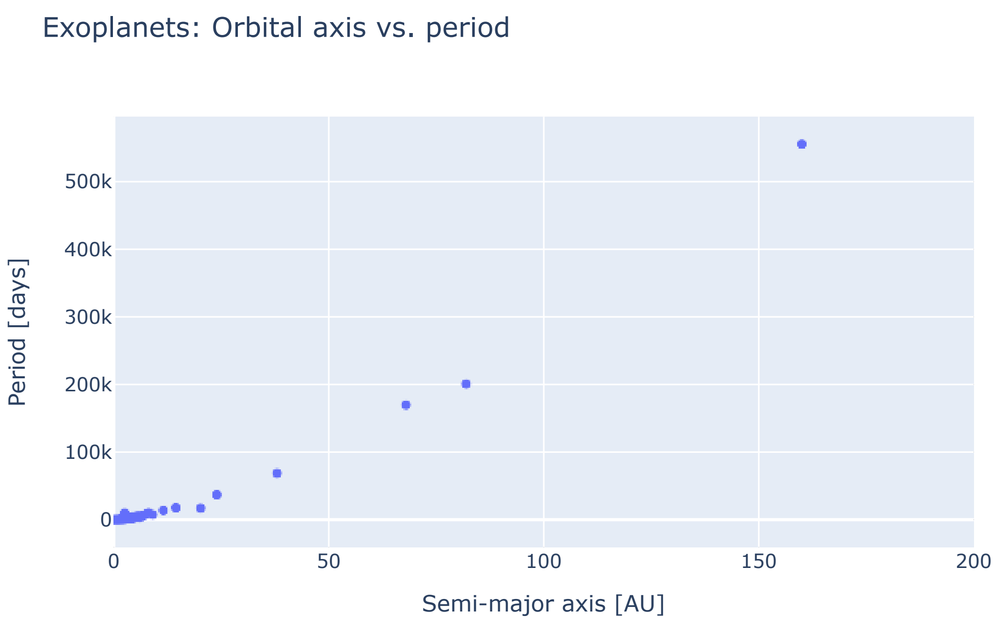
[5]:
```
planetsDf=planetsDf.drop(index=3183)
```

[6]:
```
planetsDf[['pl_orbsmax','pl_orbper']].corr()
```

[6]:

	pl_orbsmax	pl_orbper
pl_orbsmax	1.000000	0.965909
pl_orbper	0.965909	1.000000

[7]:
```
fig = px.scatter(planetsDf,x='pl_orbsmax', y='pl_orbper',title="Exoplanets:␣
↪Orbital axis vs. period",width=800, height=320)
fig.update_xaxes(range=(0,200), title='Semi-major axis [AU]')
fig.update_yaxes(title='Period [days]')
fig.show()
```



2 Error theory aproximation for planets with stars of known mass:

Applying the theory described at the beginning here is calculated the approximate result of the extrasolar planet's orbital period.

3

$$T \approx \sqrt{\frac{a^3}{\frac{GM}{4\pi^2}}}$$

With a=semi-major axis , M=Mass of star and G=Gravity

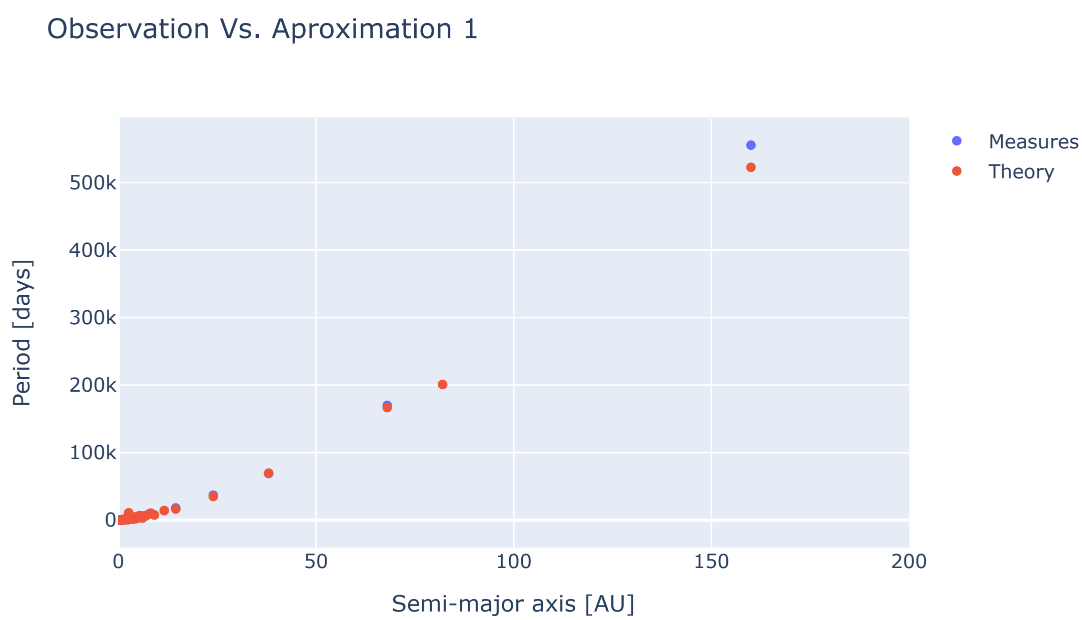
a = 'pl_orbsmax' is the semi-major axis.

M = 'st_mass' is the mass star in solar masses.

4434075.792 is a factor to use solar masses and UA units

[8]:
```
planetsDf=planetsDf[planetsDf['st_mass'].notnull()] #Erase data without star␣
↪mass stimation
theorPeriod=np.power(planetsDf['pl_orbsmax'],3/2)/np.power(6.
↪674E-11*(planetsDf['st_mass'])*4434075.792/(4*(np.power(np.pi,2))),1/2)
theorPeriod[planetsDf['pl_orbper'].isnull()]=np.nan
planetsDf['theorPeriod']=theorPeriod
```

[9]:
```
data0 = go.Scatter(x=planetsDf['pl_orbsmax'], y=planetsDf['pl_orbper'], mode =␣
↪'markers', name='Measures')
data1 = go.Scatter(x=planetsDf['pl_orbsmax'], y=planetsDf['theorPeriod'], mode␣
↪= 'markers', name='Theory')
data = [data0, data1]
layout = go.Layout(title='Observation Vs. Aproximation 1')
fig = go.Figure(data= data, layout = layout)
fig.update_xaxes(range=(0,200), title='Semi-major axis [AU]')
fig.update_yaxes(title='Period [days]')
fig.show()
#pyo.plot(fig, filename = 'line_chart.html')
```



Mean squared error:

[10]:
```
((planetsDf['pl_orbper']-planetsDf['theorPeriod'])**2).mean()
```

[10]: 721093.6716320177

More exactly: #

$$T = \sqrt{\frac{a^3}{\frac{G(M+m)}{4\pi^2}}}$$

With a=semi-major axis , M=Mass of star, m=mass of the planet and G=Gravity

a = ‘pl_orbsmax’ is the semi-major axis.

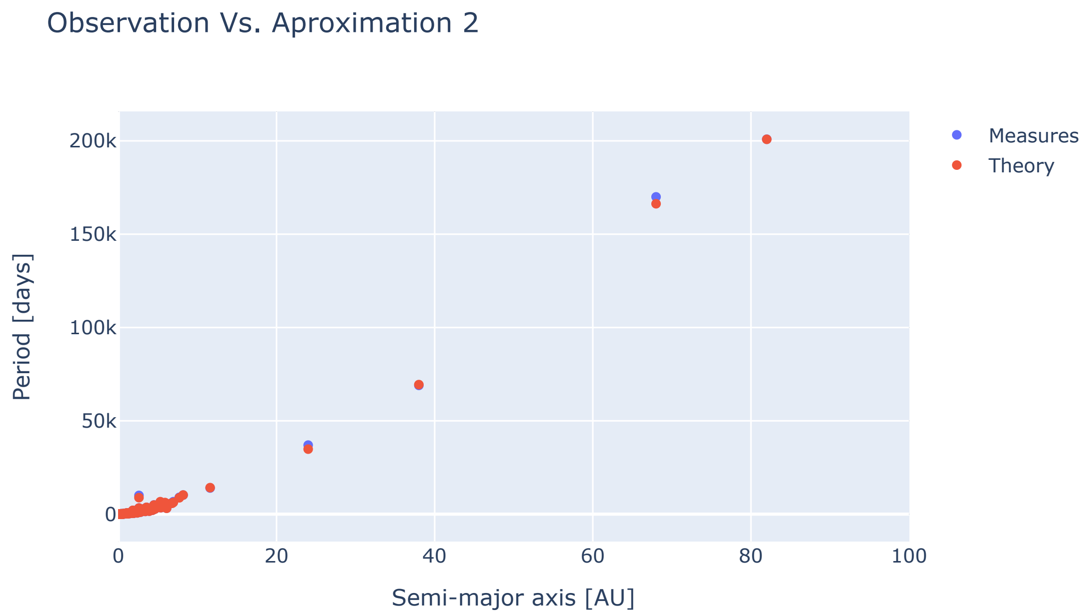
M = ‘st_mass’ is the mass star in solar masses.

4434075.792 is a factor to use solar masses and UA units

m = ‘pl_bmassj’ is the planet mass in Jupiter masses (Jupiter has $9.55 \cdot 10^{-4}$ solar masses)

[11]:
```
planetsDf=planetsDf[planetsDf['pl_bmassj'].notnull()] #Erase data without␣
↪planet mass stimation
theorPeriod=np.power(planetsDf['pl_orbsmax'],3/2)/np.power(6.
↪674E-11*(planetsDf['st_mass']+planetsDf['pl_bmassj']*9.55*10**-4)*4434075.
↪792/(4*(np.power(np.pi,2))),1/2)
theorPeriod[planetsDf['pl_orbper'].isnull()]=np.nan
planetsDf['theorPeriod']=theorPeriod
```

[12]:
```
data0 = go.Scatter(x=planetsDf['pl_orbsmax'], y=planetsDf['pl_orbper'], mode =␣
↪'markers', name='Measures')
data1 = go.Scatter(x=planetsDf['pl_orbsmax'], y=planetsDf['theorPeriod'], mode␣
↪= 'markers', name='Theory')
data = [data0, data1]
layout = go.Layout(title='Observation Vs. Aproximation 2')
fig = go.Figure(data= data, layout = layout)
fig.update_xaxes(range=(0,100), title='Semi-major axis [AU]')
fig.update_yaxes(title='Period [days]')
fig.show()
#pyo.plot(fig, filename = 'line_chart.html')
```



Mean squared error:

[13]:
```
((planetsDf['pl_orbper']-planetsDf['theorPeriod'])**2).mean()
```

[13]: 30708.99206598928

4 Conclusion:

Correlation shows relation between observed period and orbital axis. The observations conform to the theoretical calculation:

5

$$T = \sqrt{\frac{a^3}{\frac{G(M+m)}{4\pi^2}}}$$

With a=semi-major axis , M=Mass of star, m=mass of the planet and G=Gravity

The relation measured is causal.