Friedrich-Alexander-Universität
Technische Fakultät

FAU

Methods of Exoplanet Detection

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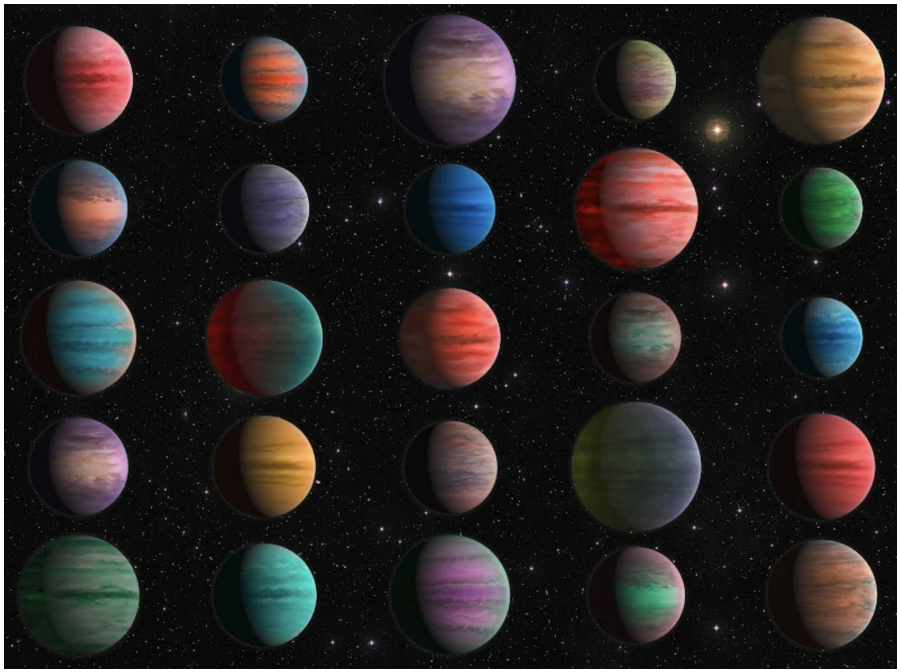
Introduction

Motivation

- Increased interest in space during the recent years
- One particular interest: Exoplanets
- This project analyses planets detected through the 5 most known techniques with one another, in order to answer the question:
- *“Are certain methods of detection able to capture only certain exoplanets?”*



Introduction

Methods of Detection

- **Radial Velocity:** This method relies on the fact that a star does not remain completely stationary when it is orbited by a planet. The star moves, ever so slightly, in a small circle or ellipse, responding to the gravitational tug of its smaller companion.
- **Pulsar Timing:** Exoplanets detected through this method orbit a pulsar, which is a rapidly rotating neutron star. As they rotate, pulsars emit intense electromagnetic radiation that is detected on Earth as regular and precisely timed pulses, which are so regular they are more accurate than an atomic clock.
- **Microlensing:** It is based on the gravitational lens effect. A massive object (the lens) will bend the light of a bright background object (the source). This can generate multiple distorted, magnified, and brightened images of the background source.
- **Direct Imaging:** This method consists of capturing images of exoplanets directly, which is possible by searching for the light reflected from a planet's atmosphere at infrared wavelengths.
- **Transit:** This method only works for star-planet systems that have orbits aligned in such a way that, as seen from Earth, the planet travels between us and the star and temporarily blocks some of the light from the star once every orbit.

Introduction

Definitions

- **Planet Mass (Earth/Jupiter):** Amount of matter contained in a planet, measured in units of masses of Earth/Jupiter
- **Planet Radius (Earth/Jupiter):** Length of a line segment from the centre of the planet to its surface, measured in units of radius of Earth/Jupiter
- **Stellar Mass:** Amount of matter contained in the star, measured in units of masses of the Sun
- **Stellar Age:** The age of a host star, measured in gigayear
- **Eccentricity:** Amount by which the orbit of the planet deviates from a perfect circle
- **Inclination:** Angle of the plane of the orbit relative to the plane perpendicular to the line-of-sight from Earth to the object, measured in degrees
- **Transit Depth:** The size of the relative flux decrement caused by the orbiting body transiting in front of the star, measured in percentage
- **Transit Duration:** The length of time from the moment the planet begins to cross the stellar limb (curved edge of an apparent disk) to the moment the planet finishes crossing the stellar limb, measured in hours
- **Galactic Longitude:** Longitude of a planetary system, measured in units of decimal degrees
- **Galactic Latitude:** Latitude of a planetary system, measured in units of decimal degrees

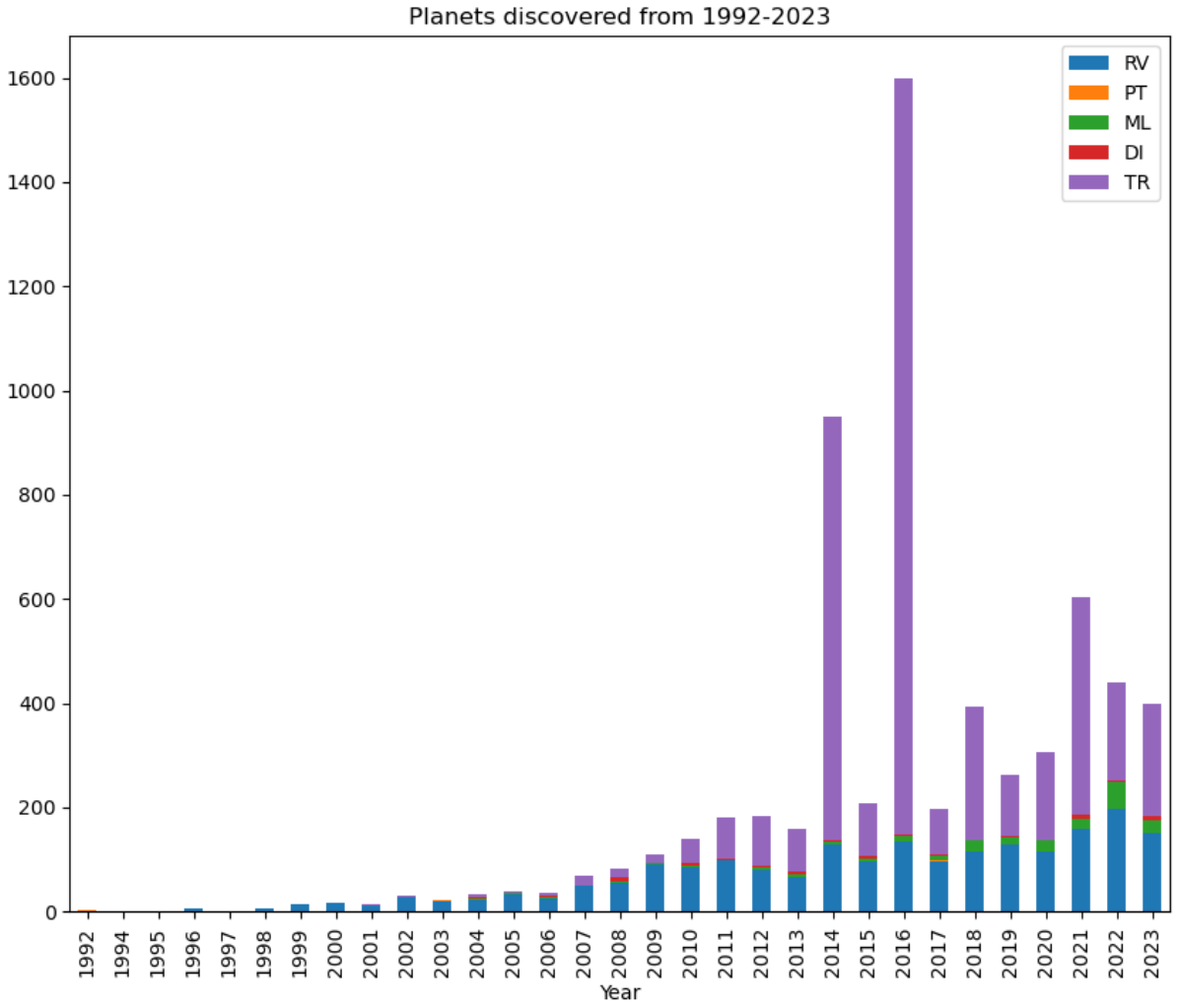
Methods and Results

Datasources

- ***Datasource 1* – Planetary Systems:** A composite data file, that will be used as a general overview, and to draw information on the two methods, Radial Velocity and Pulsar Timing, that did not have their own dataset. (Metadata, Data, Filtered Data)
- ***Datasource 2* – Microlensing:** A data file with information on all exoplanets found through the Microlensing method and their properties. (Metadata, Data, Filtered Data)
- ***Datasource 3* – Direct Imaging:** A data file with information on all exoplanets found through the Direct Imaging method and their properties. (Metadata, Data, Filtered Data)
- ***Datasource 4* – Transit:** A data file with information on all exoplanets found through the Transit method and their properties. (Metadata, Data, Filtered Data)

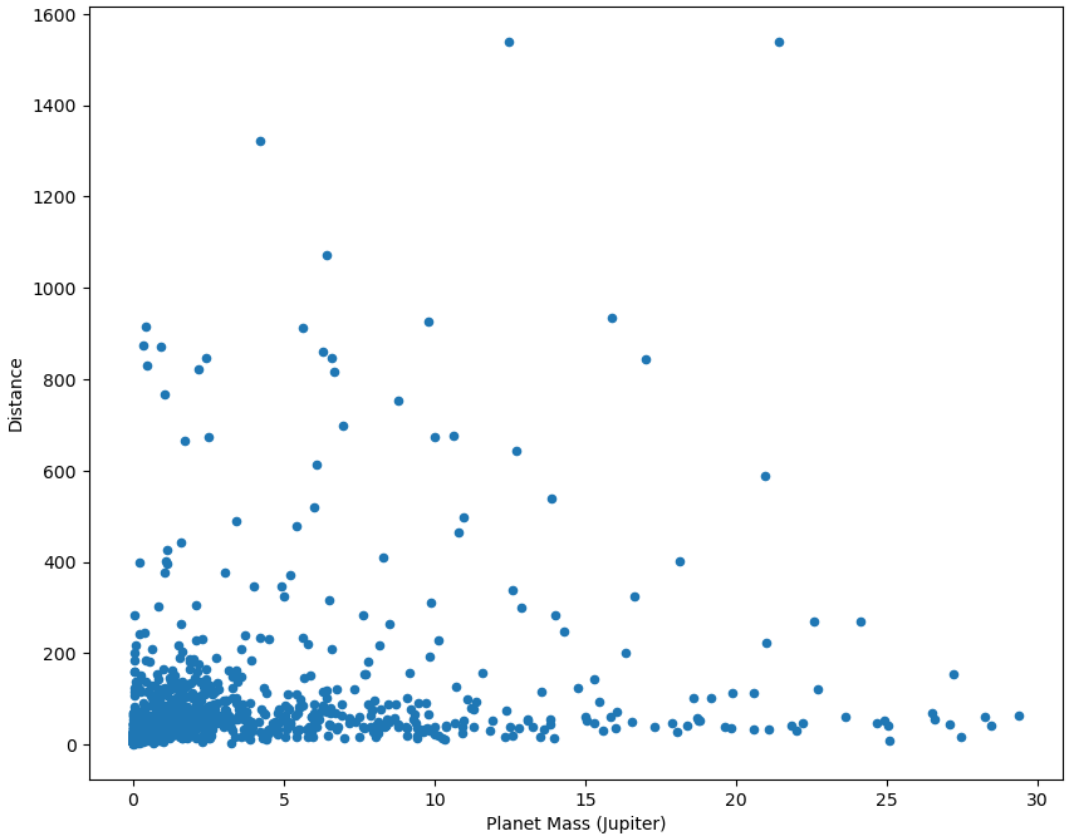
Methods and Results

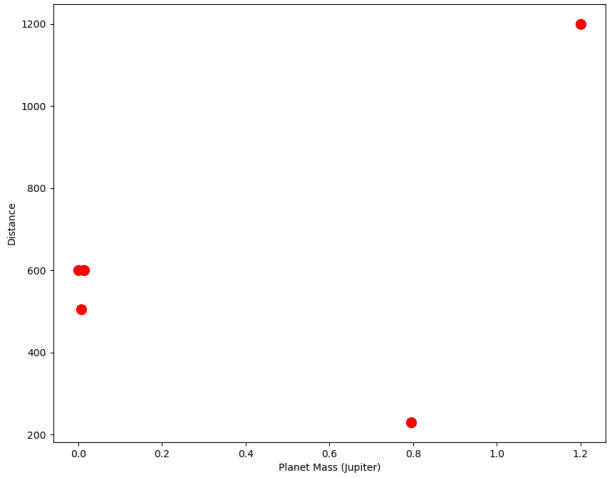
General Overview of the Methods

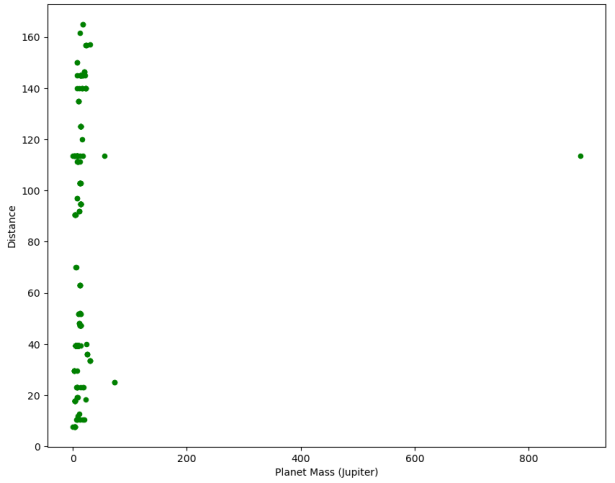


Methods and Results

Planet Mass (Jupiter) and Distance



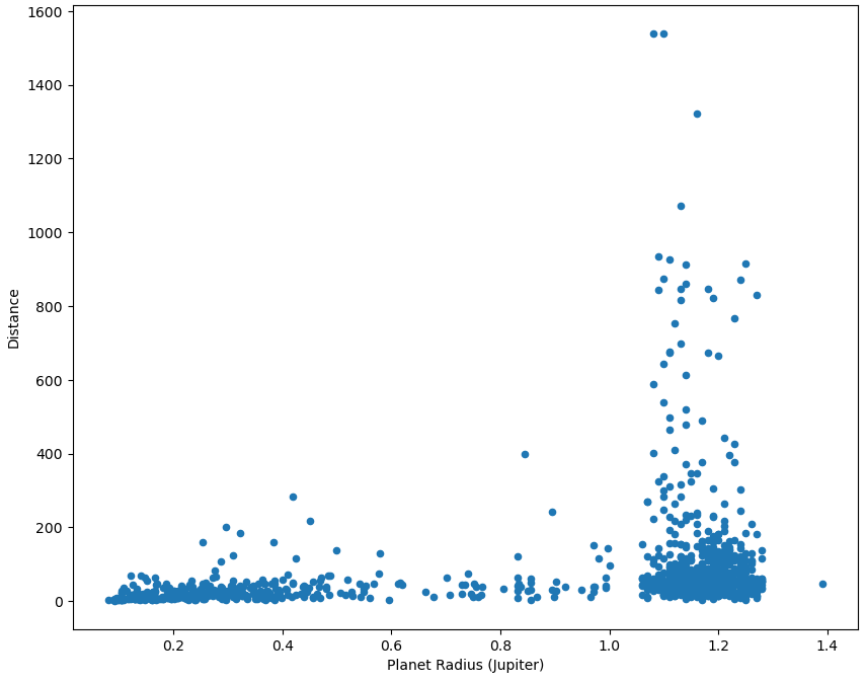


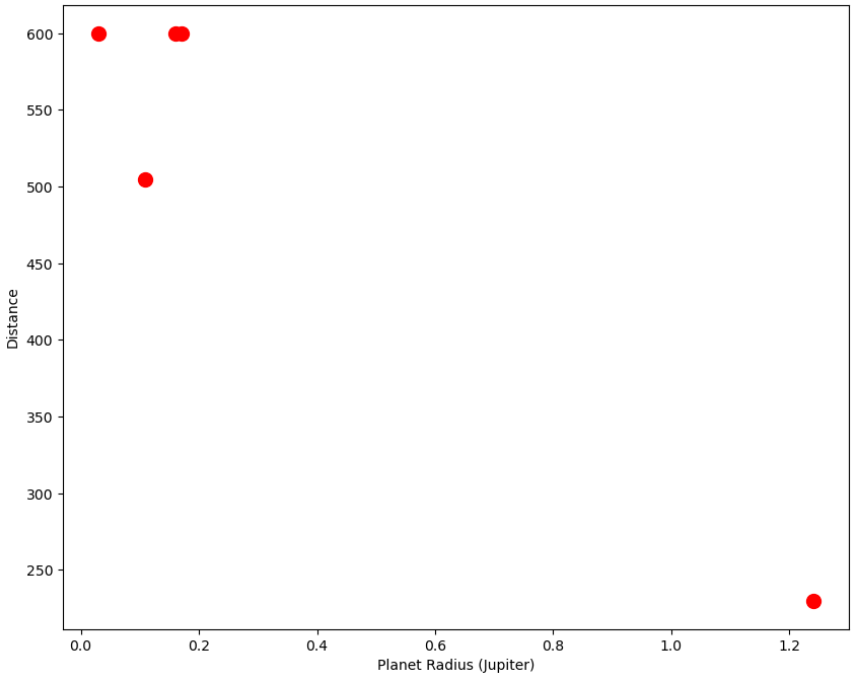


Radial Velocity detected planets have a bigger planet mass compared to the planets detected by the other methods, while **Pulsar Timing** detected planets have a much larger distance.

Methods and Results

Planet Radius (Jupiter) and Distance

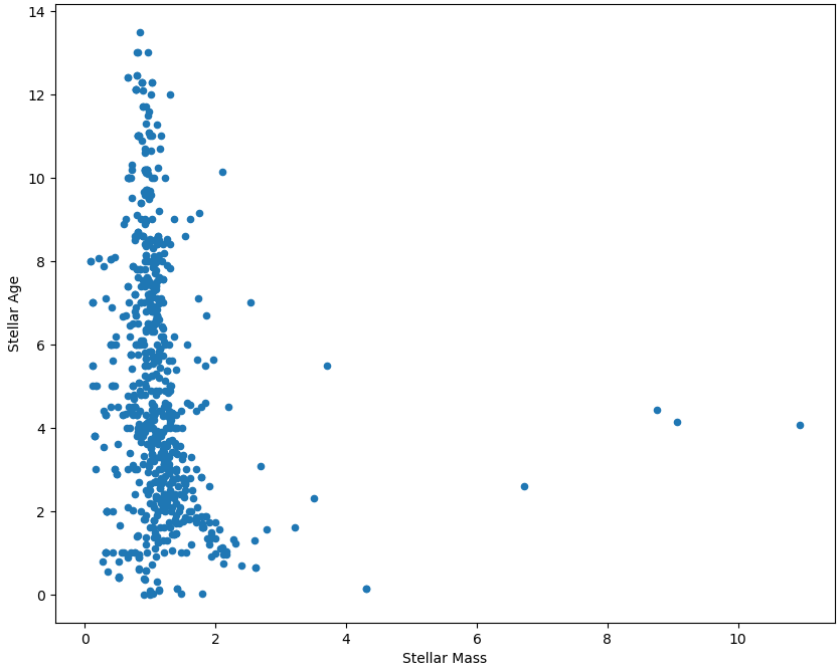


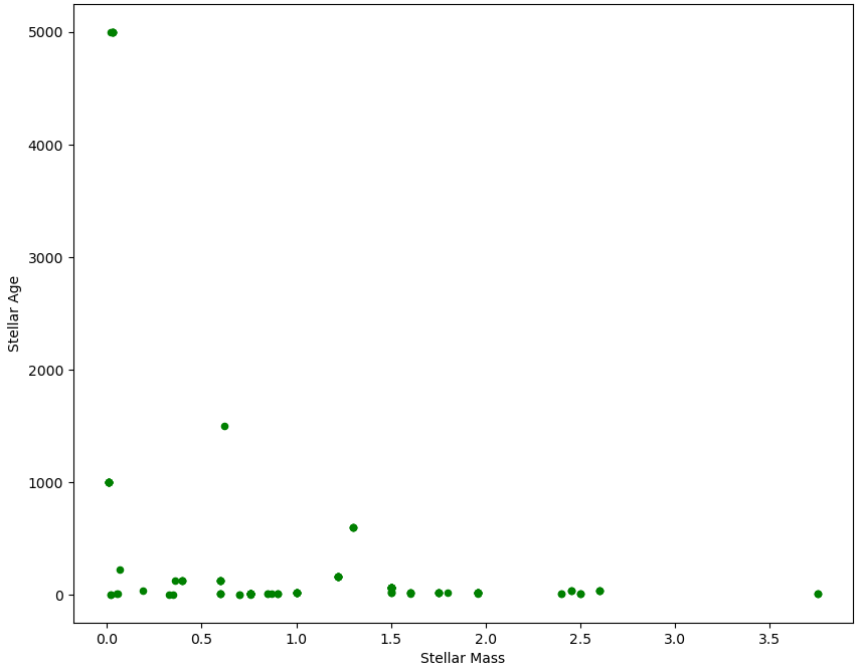


To support the previous finding, **Pulsar Timing** detected planets have a larger distance compared to other planets, but not a bigger radius.

Methods and Results

Stellar Mass and Stellar Age

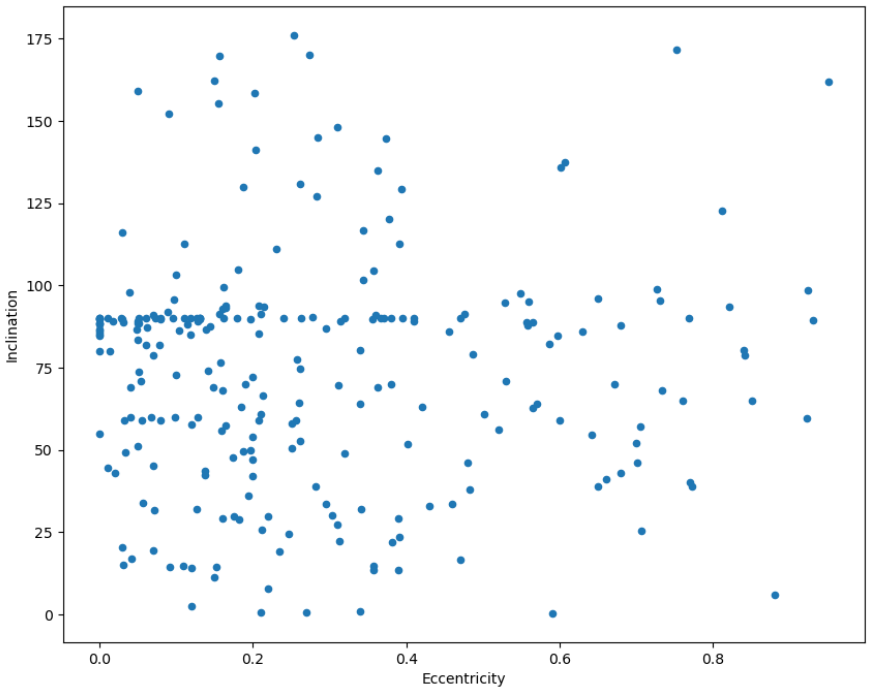


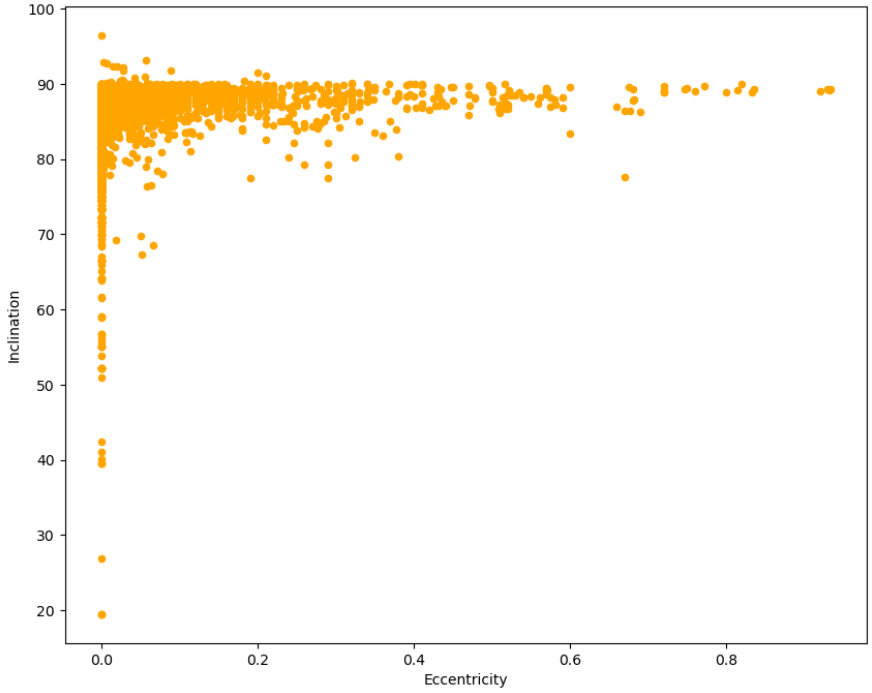


Planets detected through **Radial Velocity** have a larger stellar mass, but planets detected through **Direct Imaging** tend to have a bigger stellar age.

Methods and Results

Eccentricity and Inclination

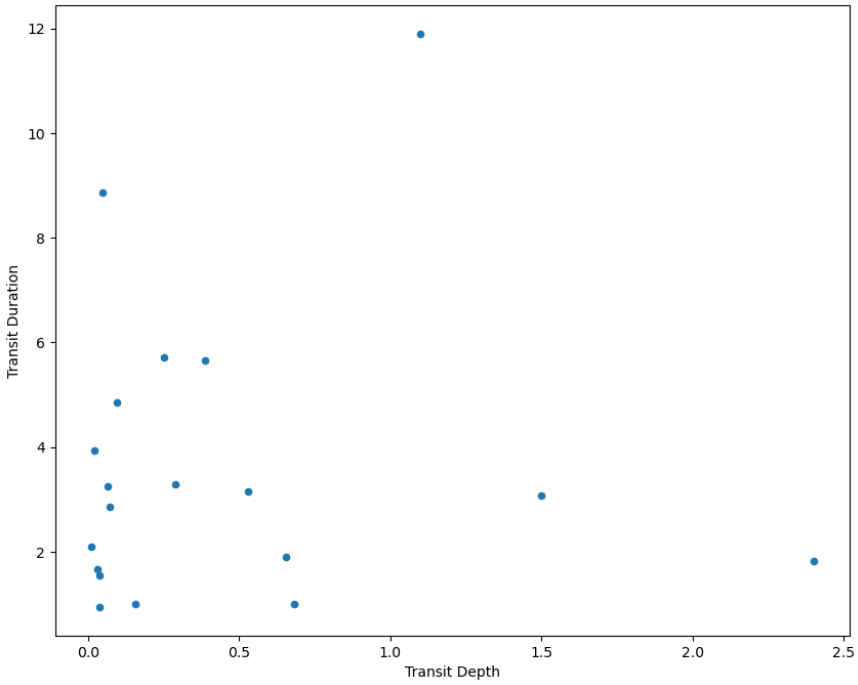


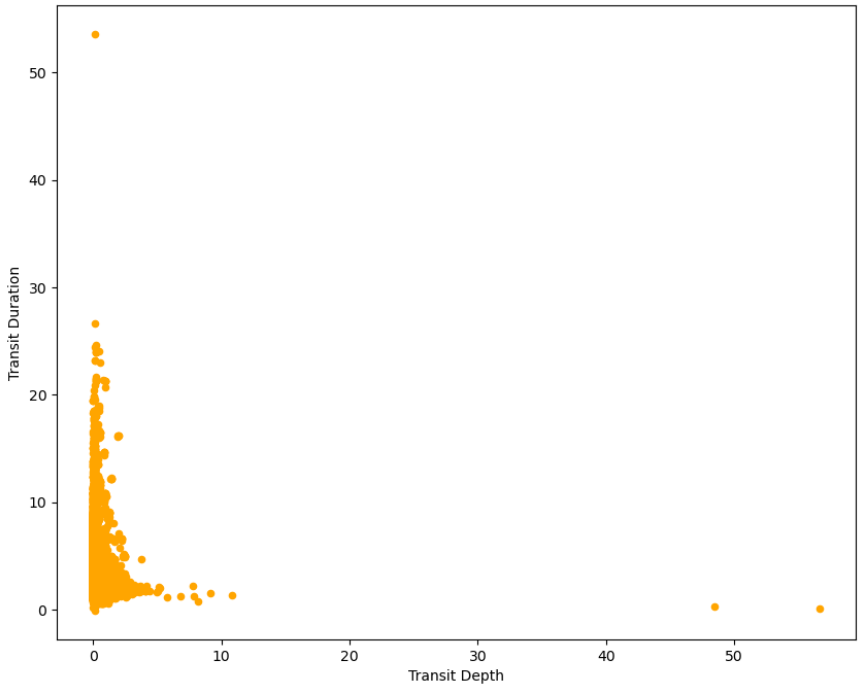


Some planets detected through **Radial Velocity** may have a bigger eccentricity, but the **Transit** detected planets have a relatively larger inclination, but not by a big margin.

Methods and Results

Transit Depth and Transit Duration

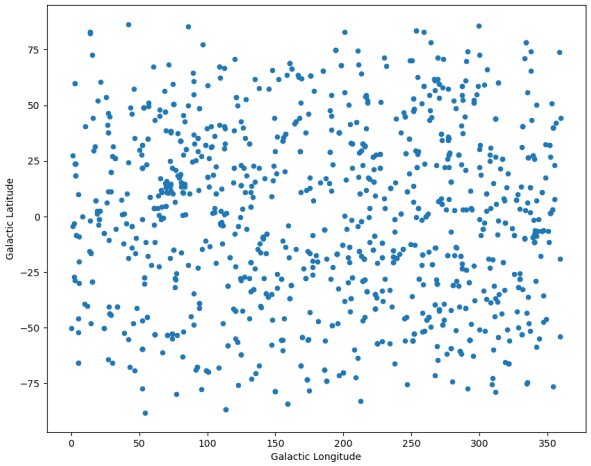


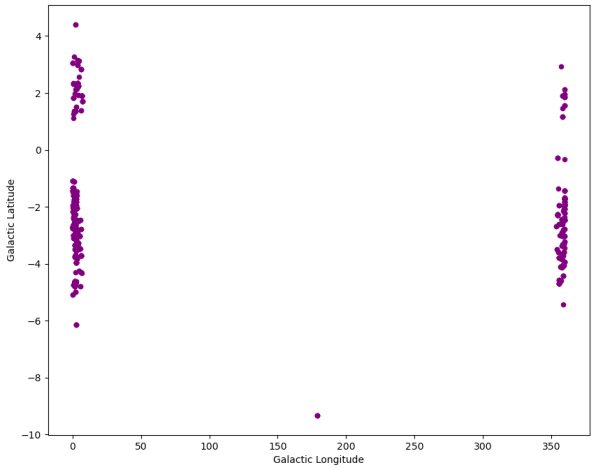


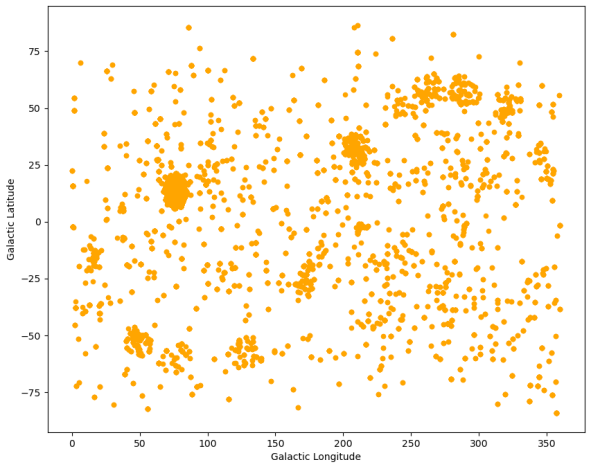
Not only some planets detected through the **Transit** method reach a bigger depth compared to other planets, but also their transit duration is way higher.

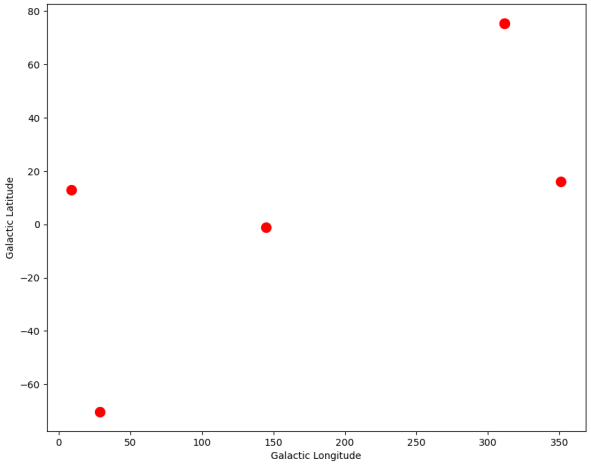
Methods and Results

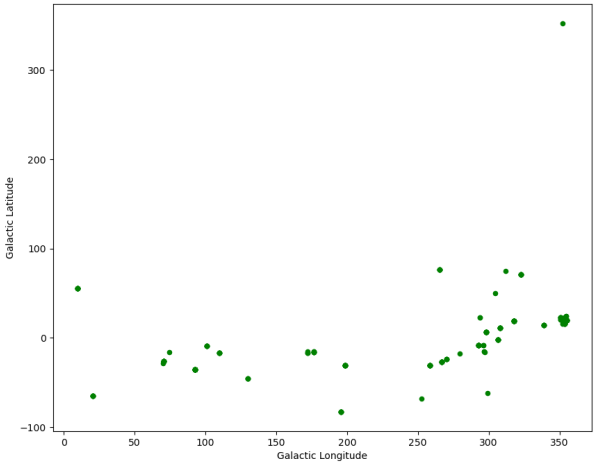
Galactic Longitude and Galactic Latitude







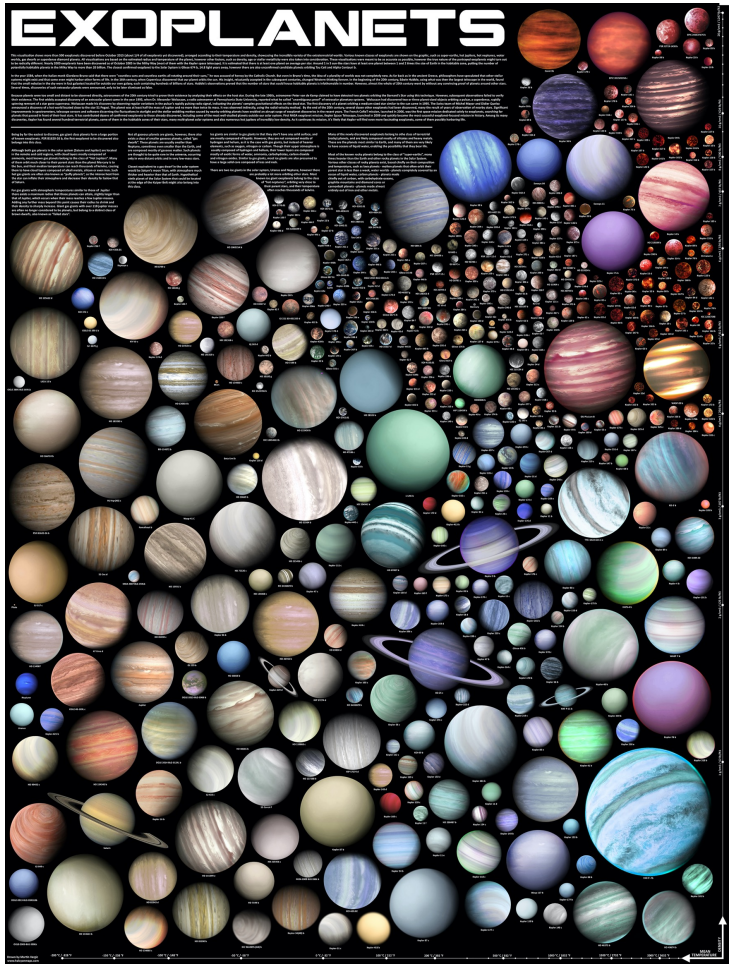




While all other methods have detected planets with a galactic longitude of around 0°, **Direct Imaging** detected planets fall under the 250° up to 350°, but in contrary with other planets, their latitude is rather small. Planets detected through **Radial Velocity**, **Pulsar Timing**, and **Transit** have a bigger range when it comes to the galactic latitude, and some of these planets can reach up to 75°.

Conclusion

Take-aways and Limitations



- *“Are certain methods of detection able to capture only certain exoplanets?”*
- Ultimately, it seems that the planets’ properties have minor significance on the methods that detect them
- Although the analysis was possible, the data was not sufficient to draw a clear answer to the main question
- Limitations: Missing data and Unique data for each detection method

Thank you for your Attention!