Planet Hunting, The Woodhouse Way

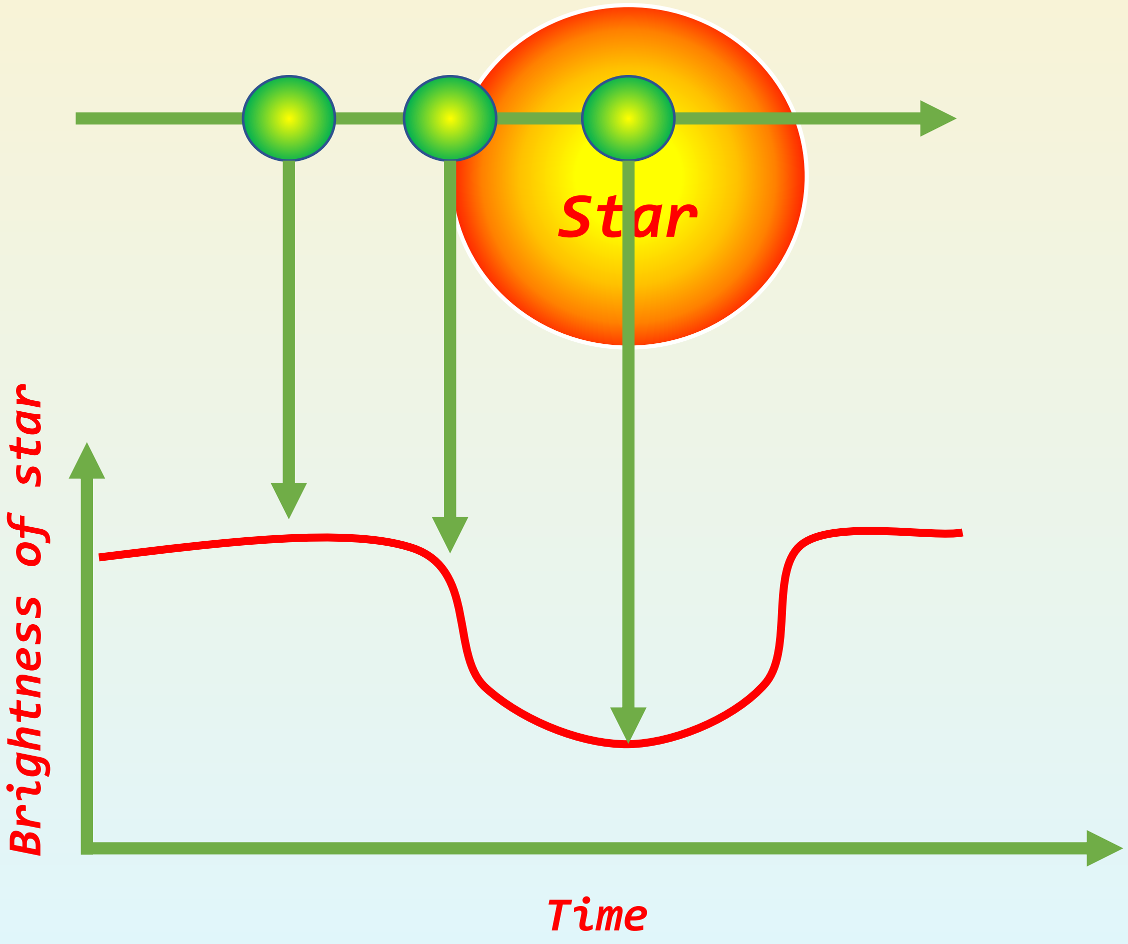
Using python to look at Kepler Planet systems via using Kepler 9 data from NASA.

The physics behind the project

- An exoplanet is a planet that orbits its local star
- Kepler data is recordings of a star’s flux (light or brightness), when the star’s flux decreases there is a planet orbiting the star.

The physics behind the programming

- Using data found from Nasa’s Kepler missions
- Detecting planets via the periodic diming of stars when the planet orbits them
- Python allows us to simulate and plot graphs so we can observe this process(image to the side)



Starting our project: Equations

We rearranged and solved equations so that from the data we can get a planets :

- **Radius from the light curve :** $\frac{\Delta L}{L_s} = \frac{R_p^2}{R_s^2}$
  - **Code version of the equation:**
```
print("planet radius: " + str(round(planetaryRadius / 1000,2)) + "km")
print("planet radius in term of earth " + str(round(planetaryRadius / radiusOfEarth,2)) + " Earth Radii")
```

- **Orbital Period (days):**
  - **Code version of the equation:**
```
print("orbital period: " + str(round(period2,2)) + " days")
```

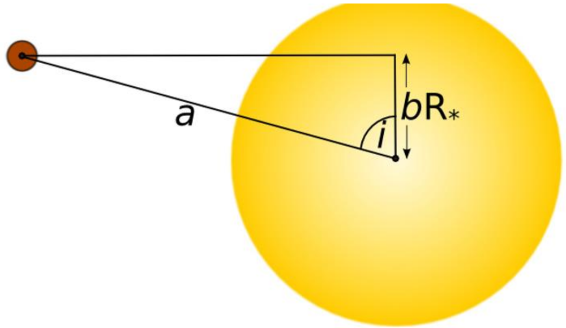
$$T_{dur} = \frac{P}{\pi} \sin^{-1}\left(\frac{\sqrt{(R_* + R_p)^2 - (bR_*)^2}}{a}\right)$$

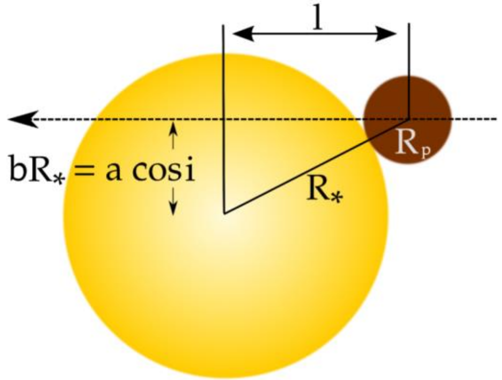
- **Mass of the star**
  - **Code version of the equation:**
```
print("mass of star: " + str(round((4*(np.pi)**2 * planetaryRadius**3)/(universalGravityConstant*((transitEnds2 - transitBegins2))**2)/1.989 * 10**30,3)))
```

- **Transit impact parameter: *b***
  - **Code version of the equation:**
```
print("transit impact parameter: " + str(round(np.sqrt((stellarRadius + planetaryRadius)**2 - np.sqrt(np.cbrt(period2**2) * math.sin(np.pi / period2) * ((transitEnds2 - transitBegins2)/8))),4)))
```

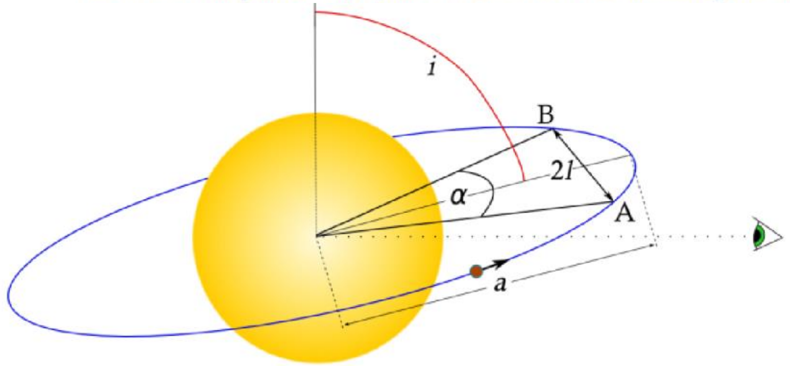
- **Planet orbital inclination:** $i = \cos^{-1}(b\frac{R_*}{a})$
  - **Code version of the equation:**
```
print("planet orbital inclination: " + str(round(i*(180/np.pi),4)) + " degrees")
```

- **Semi-major axis (AU):** $\frac{G\, M_s M_p}{a^2} = \frac{M_p\, v^2}{a} \rightarrow g = \frac{G\, M_s}{R_s^2}$
  - **Code version of the equation:**
```
print("semi-major axis: " + str(round(np.cbrt((period2)**2),2)) + "AU")
```





Face-on view of the path taken by a planet as it crosses the stellar disc during a transit.



3-dimensional view of the path taken by a transiting planet on its orbit.

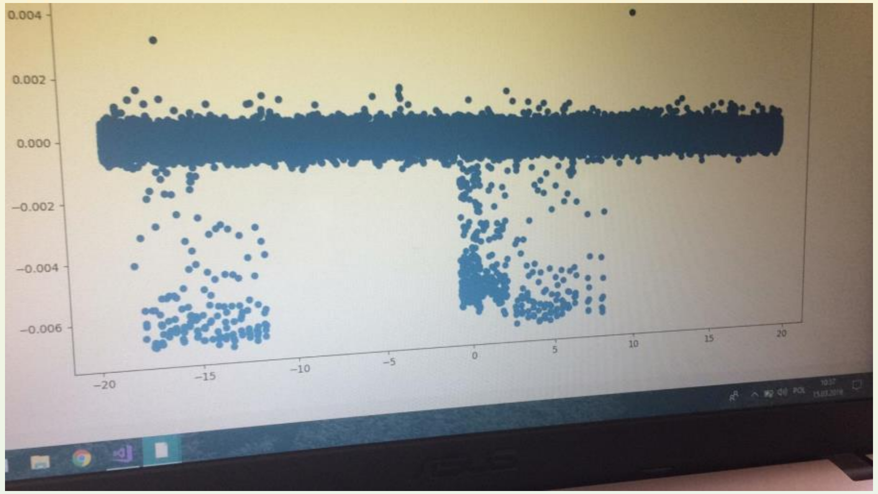
Project: Kepler 9

We wanted to push ourselves and look at more exoplanets.

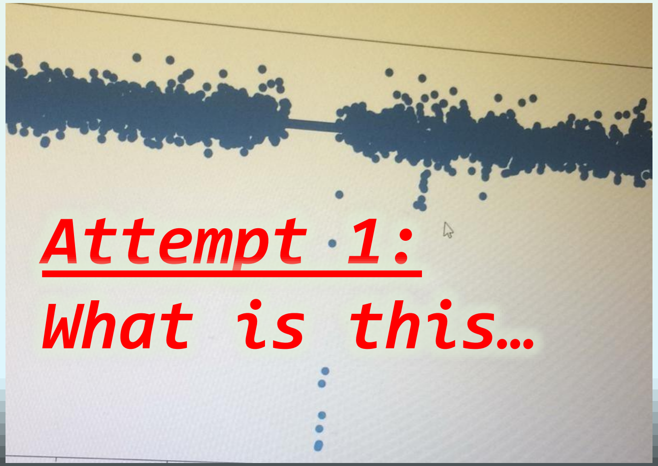
We decided to look at multi planetary systems, detect planets and separate them to create separate graphs for each, and then find out features of the planets that orbit the same star (e.g mass)

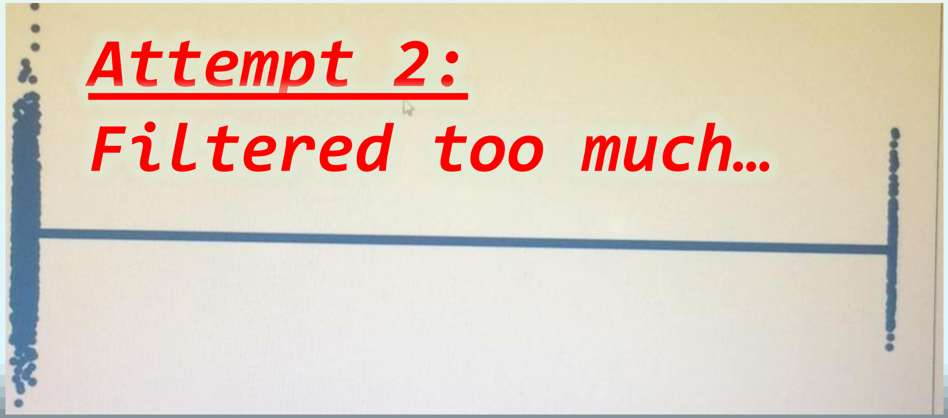
- Transit timing variation: Kepler 9 (the time it takes for the planets to orbit the star varies each time since they're interfering with each others gravitational fields)
- We completed several exercises to familiarize ourselves with python and the data itself
- Our extended projects final code is on the next slide…

Getting the filter working…

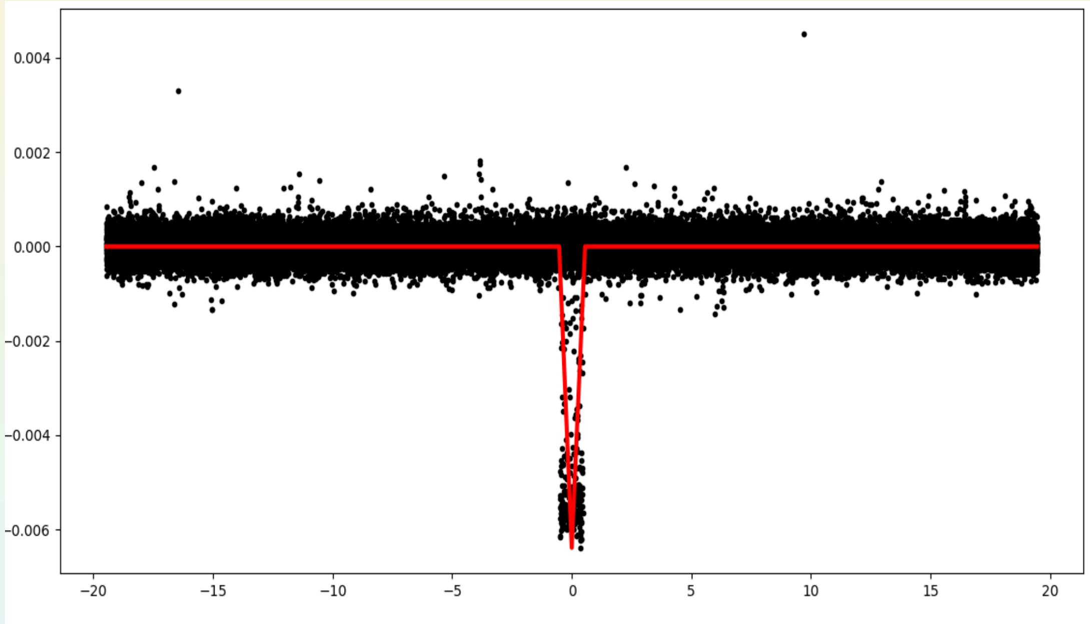


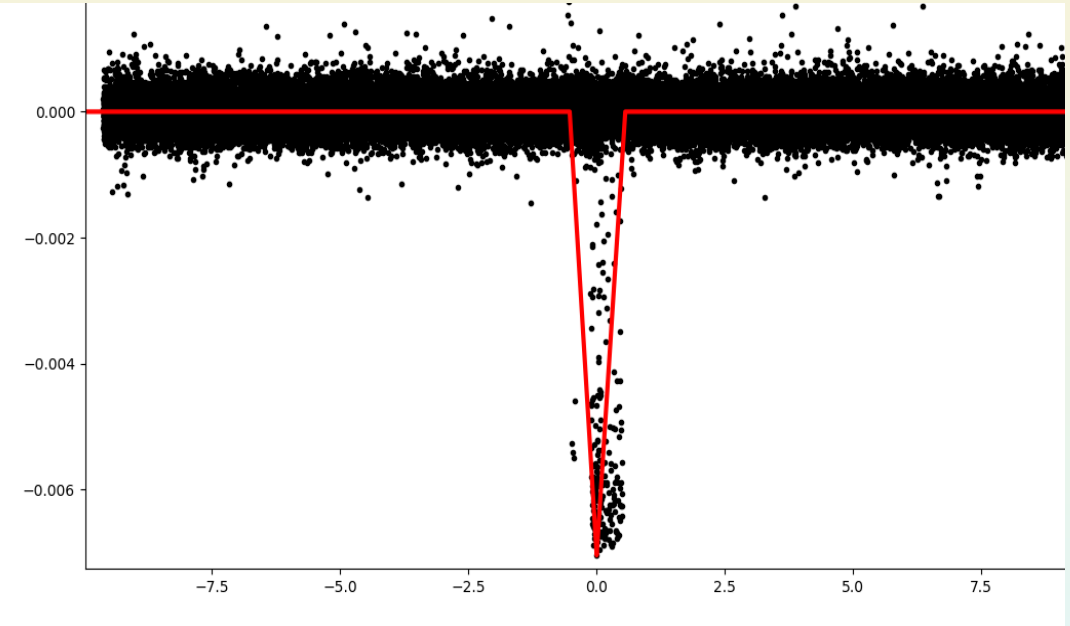
Here is the slightly filtered data plotted on a graph.(phase folded both planets on one graph)





Filter success!

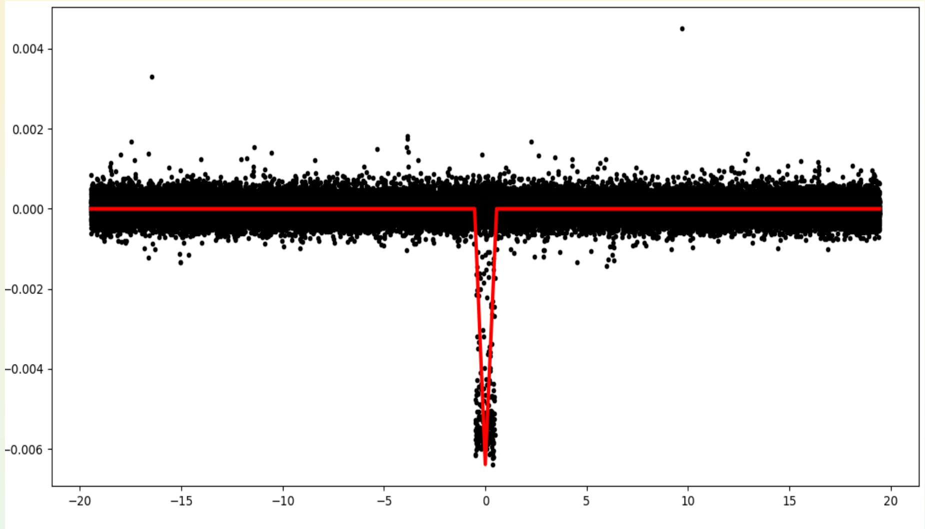




Code outputs

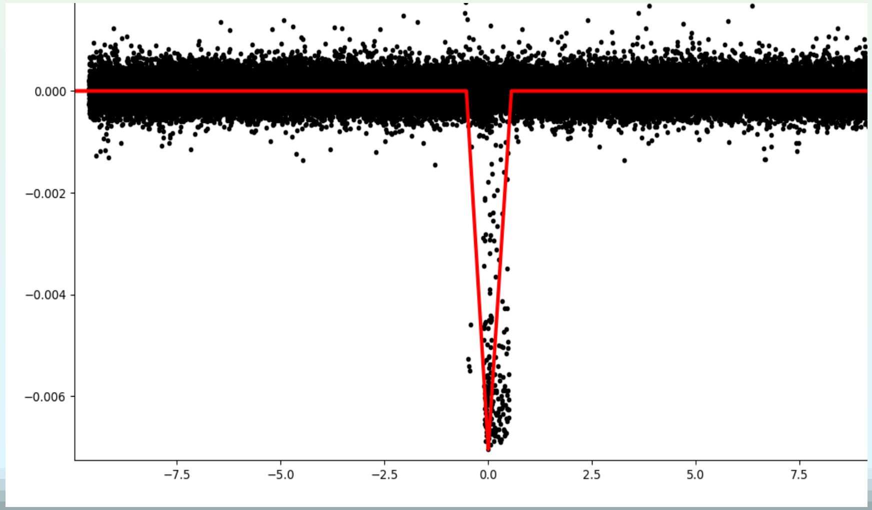
First planet:

```
-1.091664458371679e-05
1.3647212246899796e-07
-0.0063839429
planet radius: 80655.49km
planet radius in term of earth 12.66 Earth Radii
orbital period: 38.9 days
semi-major axis: 11.48AU
mass of star: 1.326765893099814e+65
transit impact parameter: 80655487.5075
planet orbital inclination: 89.018 degrees
```



Second planet:

```
-1.3115941980937955e-05
1.5929215702373257e-07
-0.0070391046
planet radius: 84693.12km
planet radius in term of earth 13.29 Earth Radii
orbital period: 19.24 days
semi-major axis: 7.18AU
mass of star: 2.1548687546427204e+65
transit impact parameter: 84693120.1074
planet orbital inclination: 88.6743 degrees
```



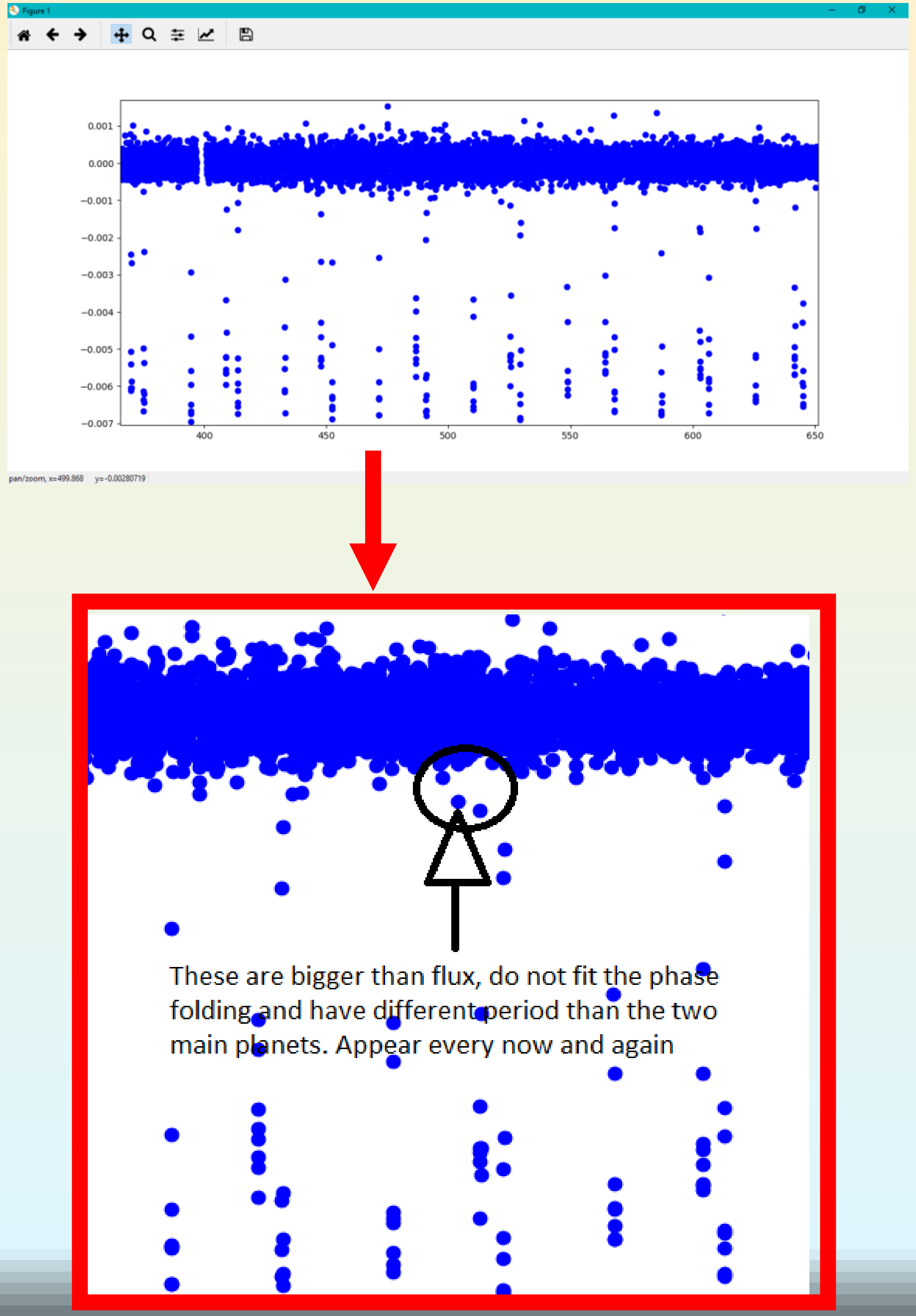
Analysis

Two planets:

- Found that there are definitely two planets and features of those planets…

Third planet theory:

- We researched further and found that there are parts of the data that suggest there are three planets rather than 2. This is because there seems to be another smaller planet since there is a subtle difference in the data.
  In the zoomed in picture of the data (highlighted) there is a big enough difference to suggest that there might be more than two planets.



Thank you for your attention!

Special Thanks to Mr Makepeace for helping us in times of need and also Professor Nelson for coming and helping us further when thinking about developing our project!