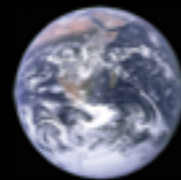
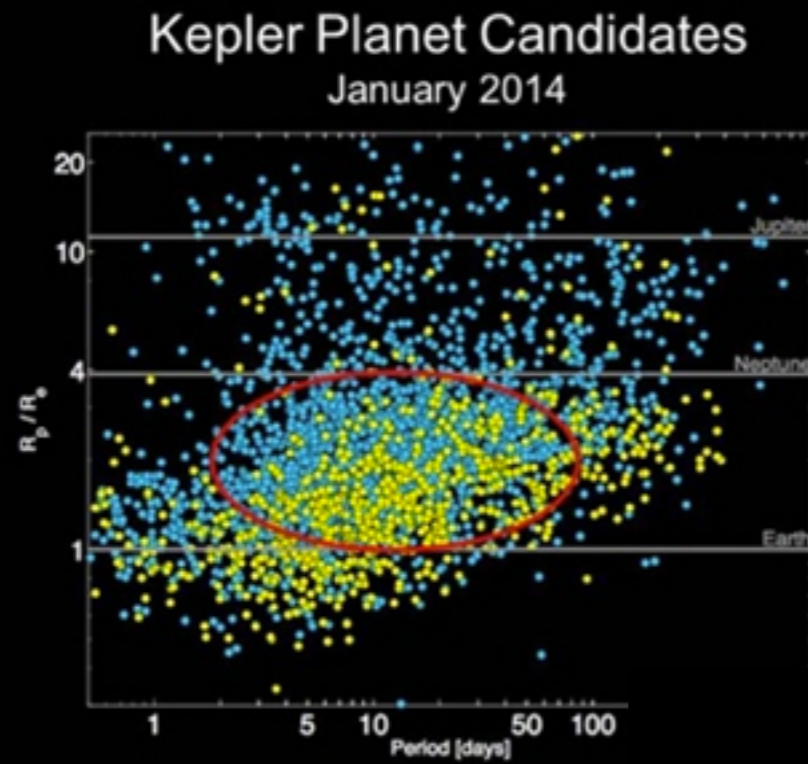


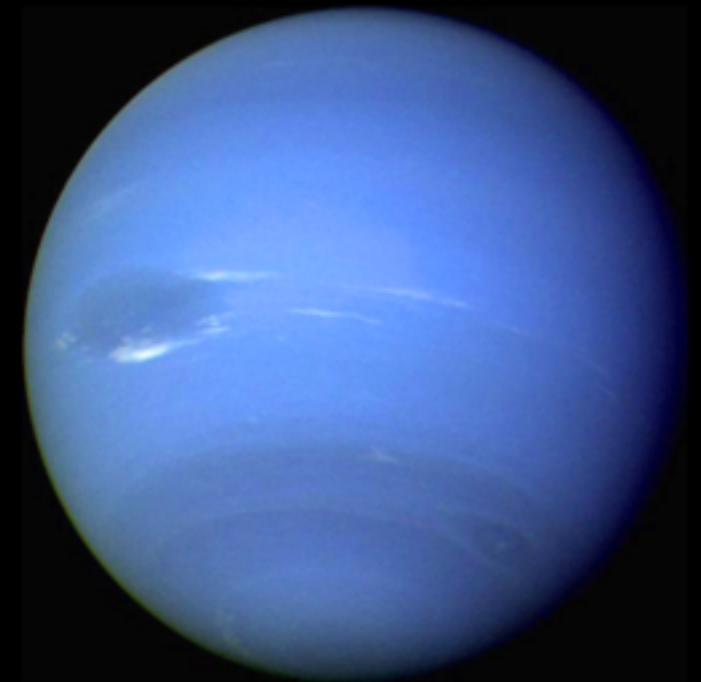
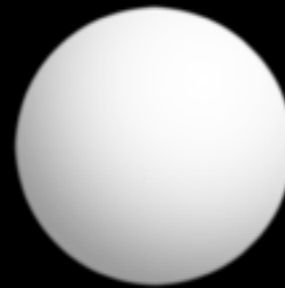
Characterizing *Kepler* Planets with TTV

Sam Hadden

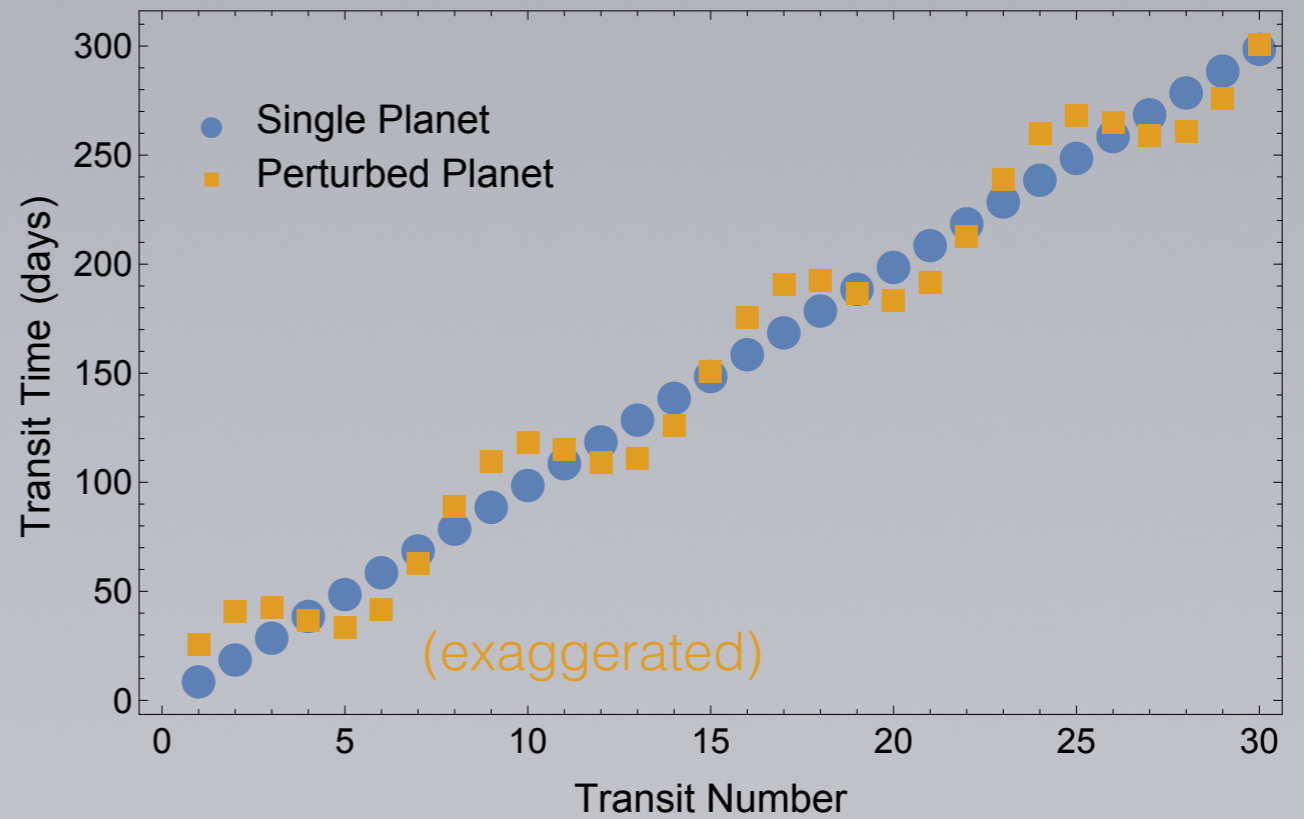
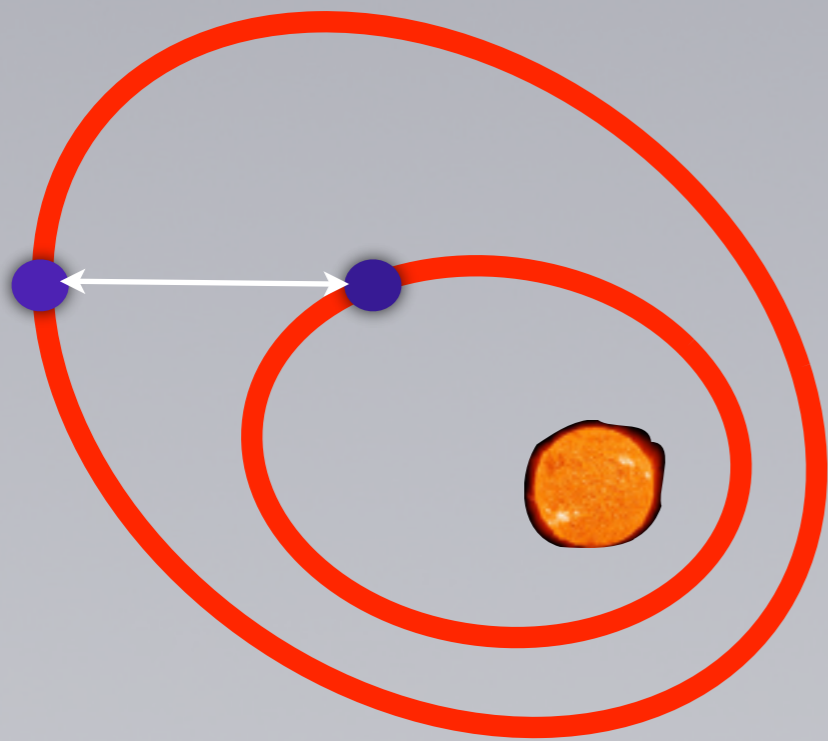
What are Kepler planets like?



?



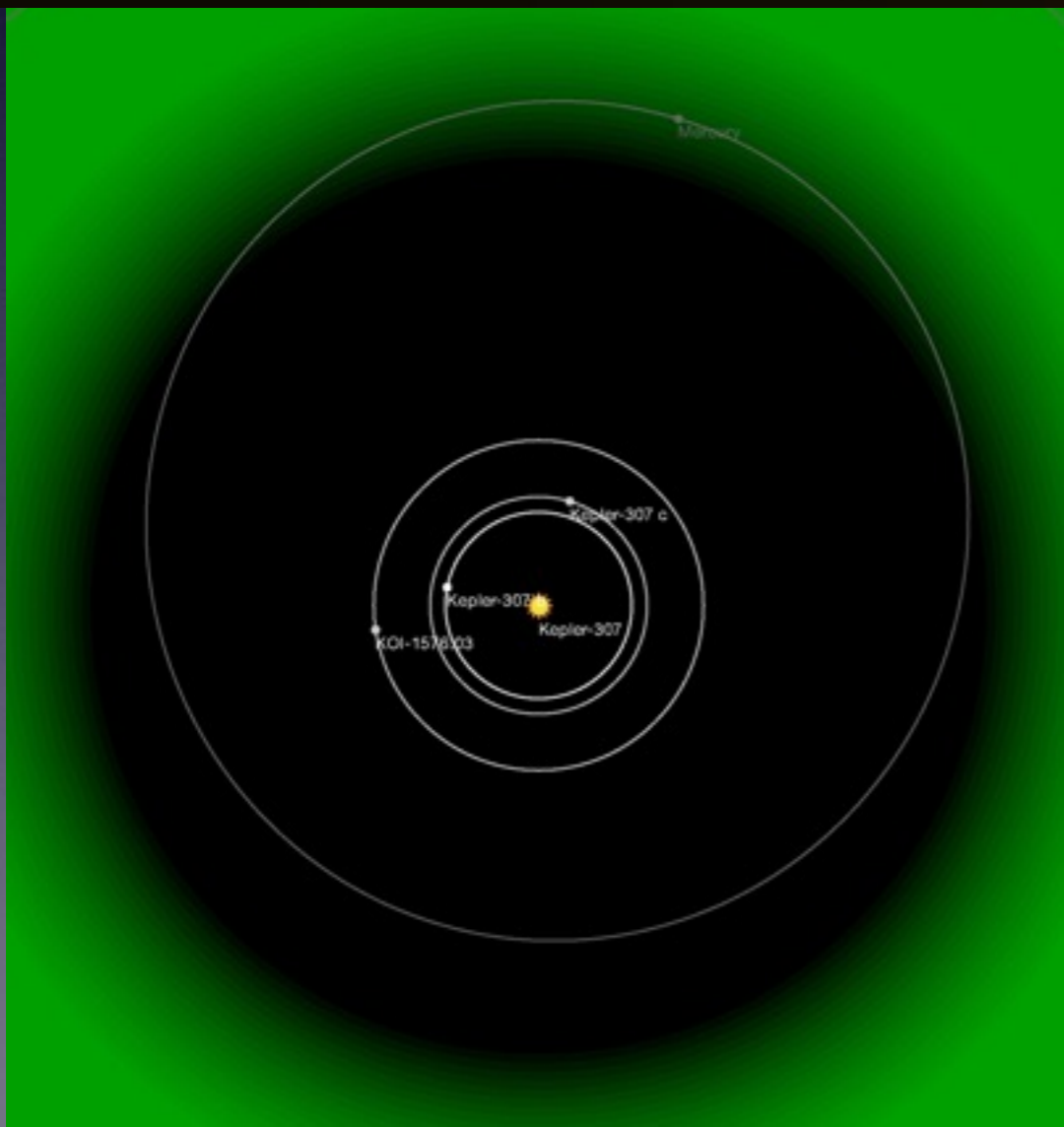
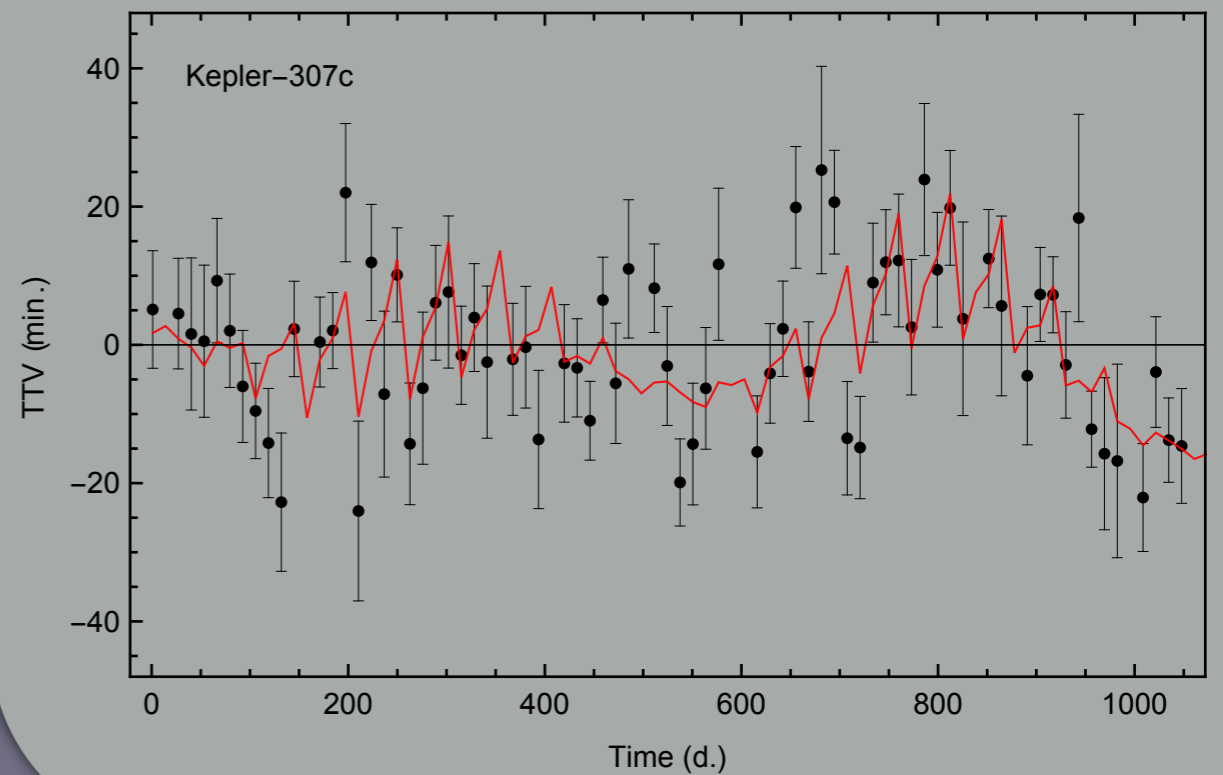
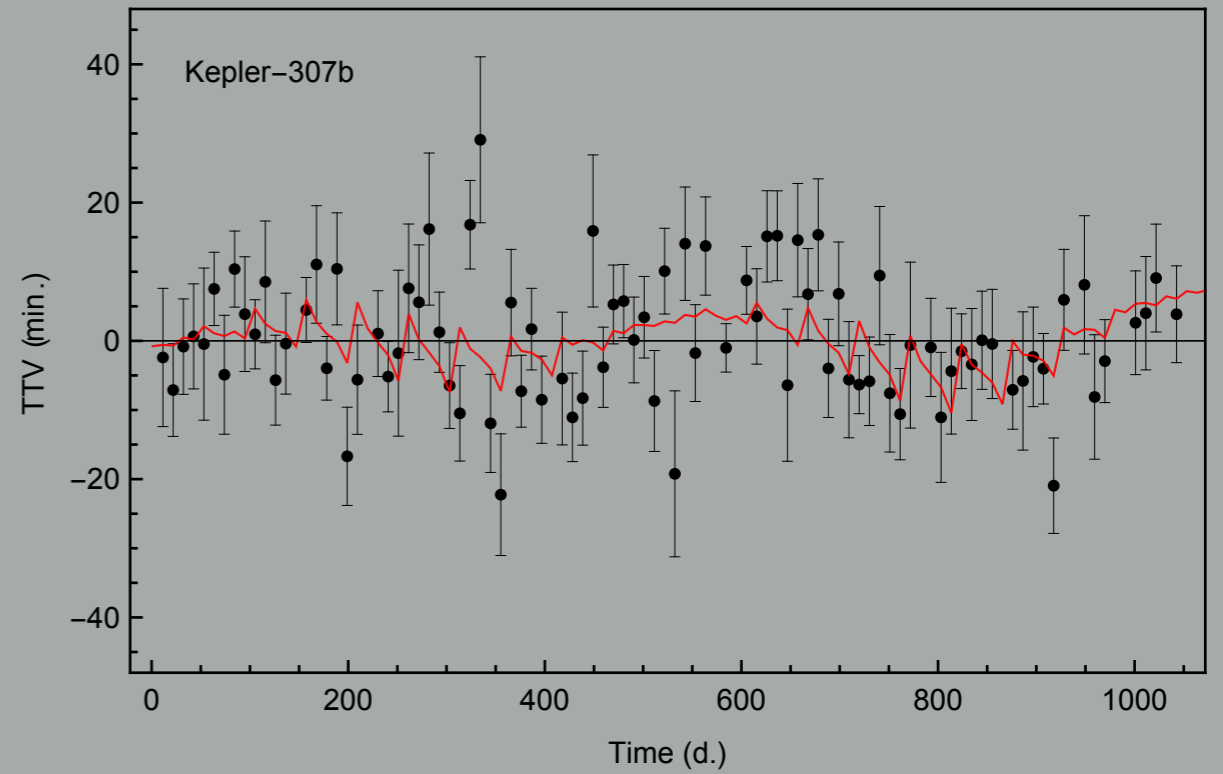
Transit Timing Variations



Example: Kepler-307



Transit Timing Variations

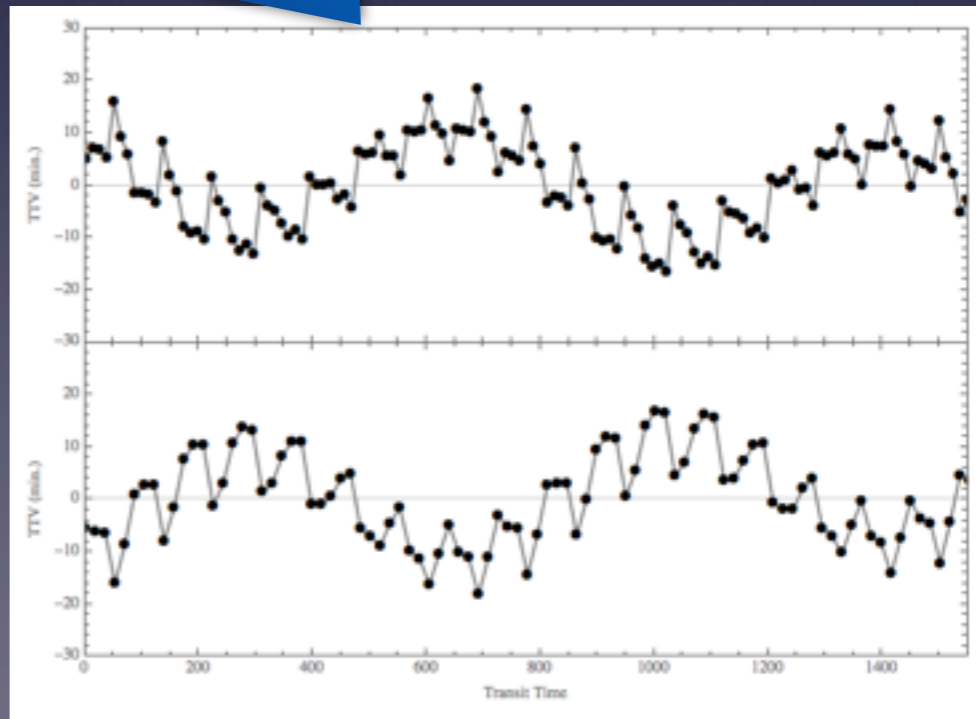


Easy!



$$\{\mu_i, a_i, e_i, \lambda_i, \varpi_i\}$$

(Planet masses & orbits)



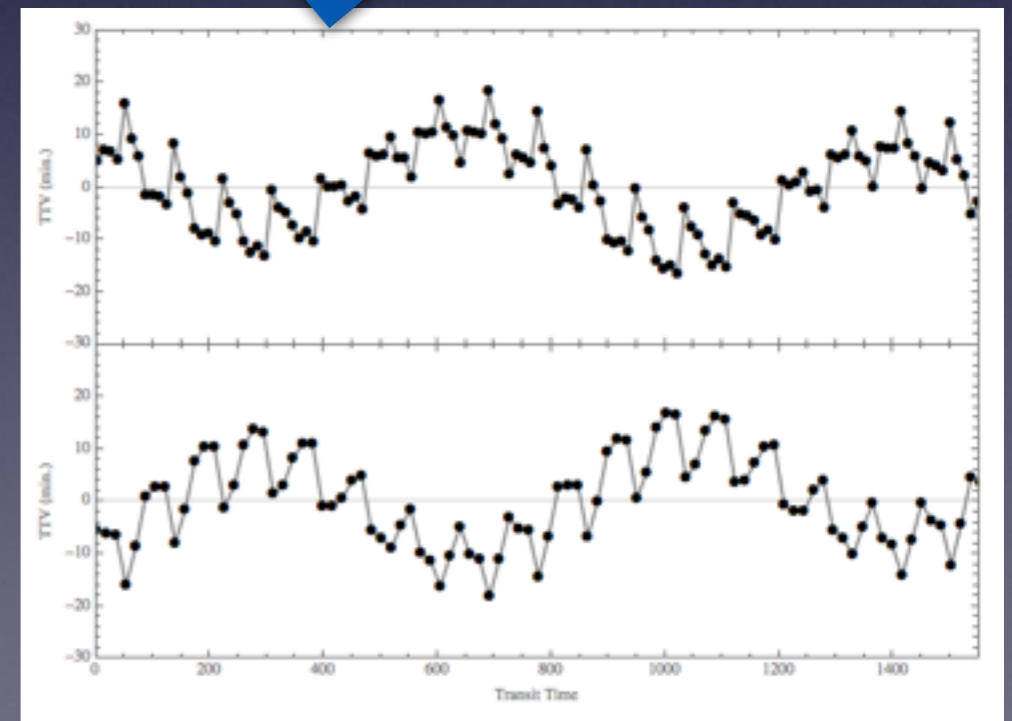
(TTVs)

Hard!



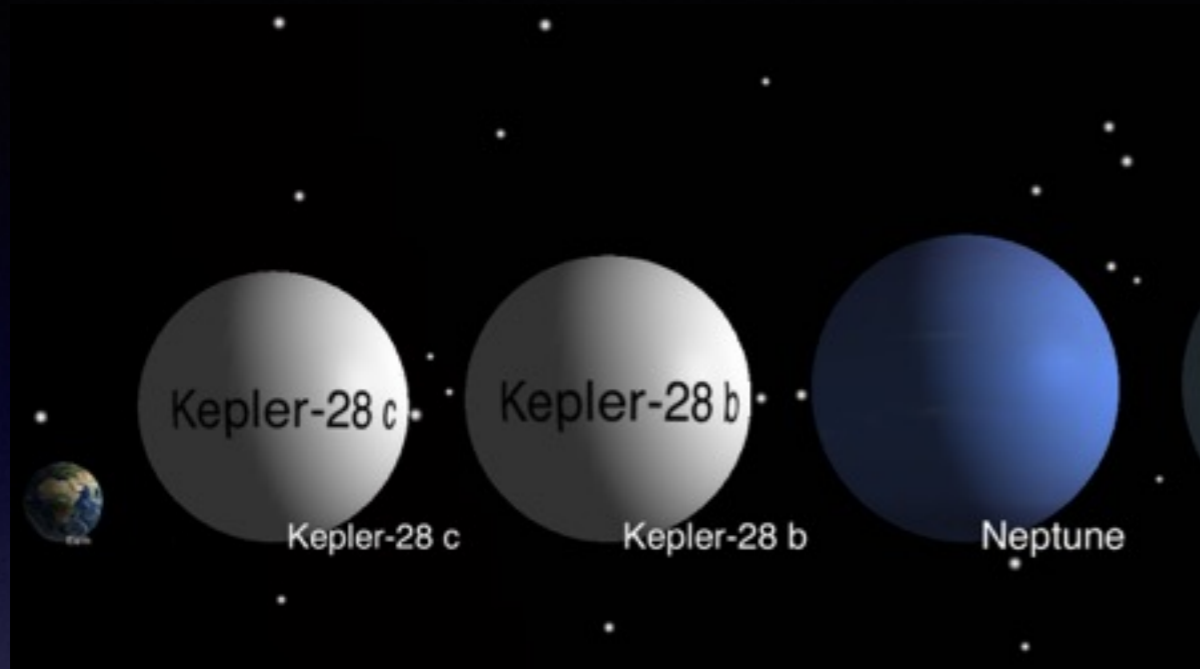
$$\{\mu_i, a_i, e_i, \lambda_i, \varpi_i\}$$

(Planet masses & orbits)

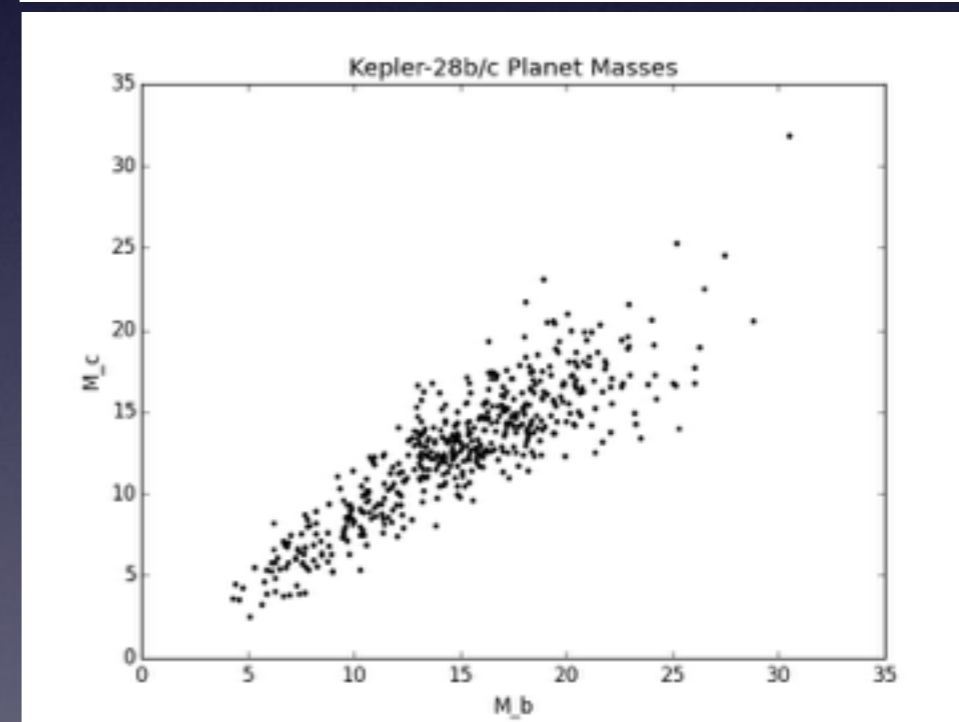
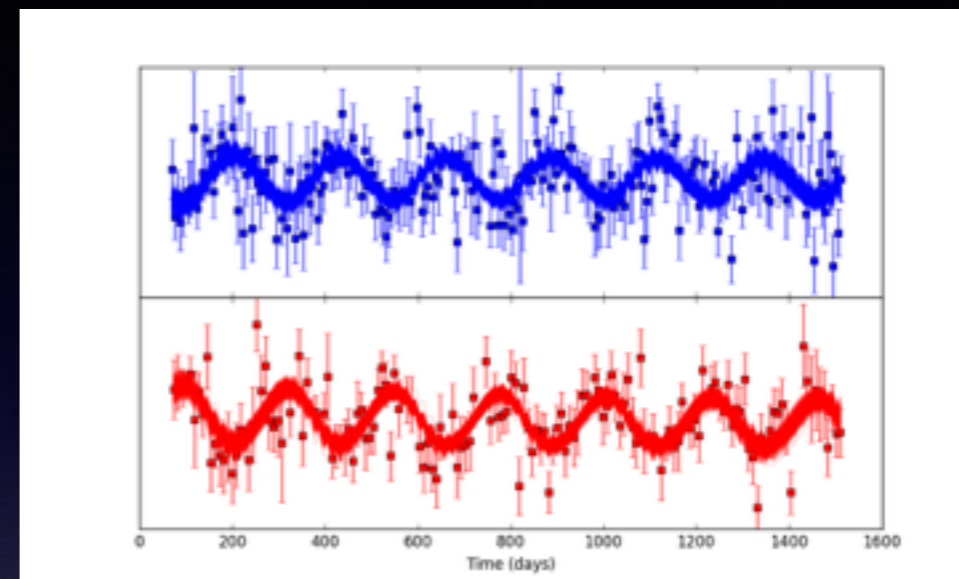


(TTVs)

Why is 'Inverting' TTVs Difficult?



- **Example:** 500 different sets of parameters with nearly the same TTVs
- TTV depends on all planet masses, positions, and velocities
- Too many parameters: random guessing won't work!



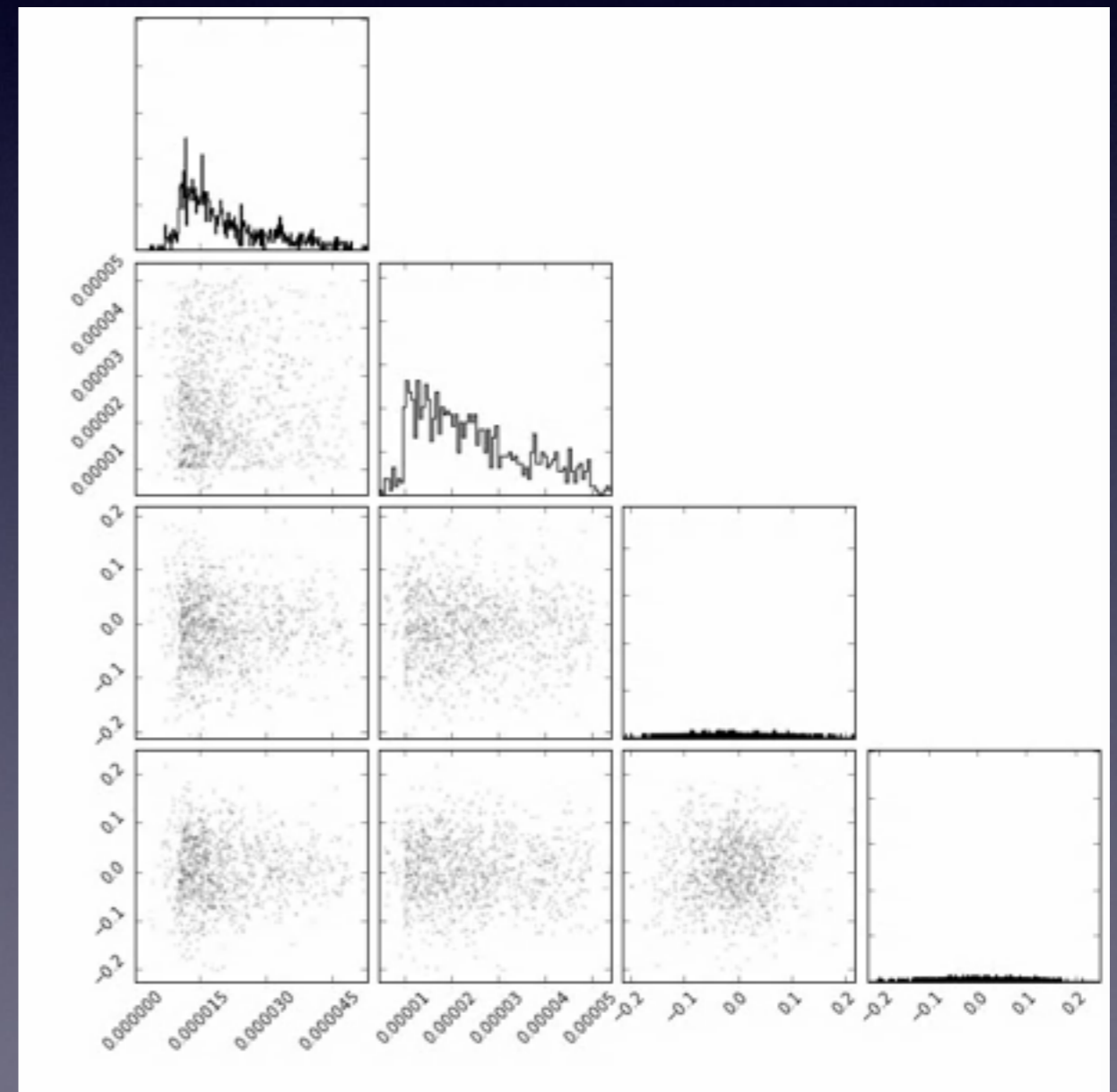
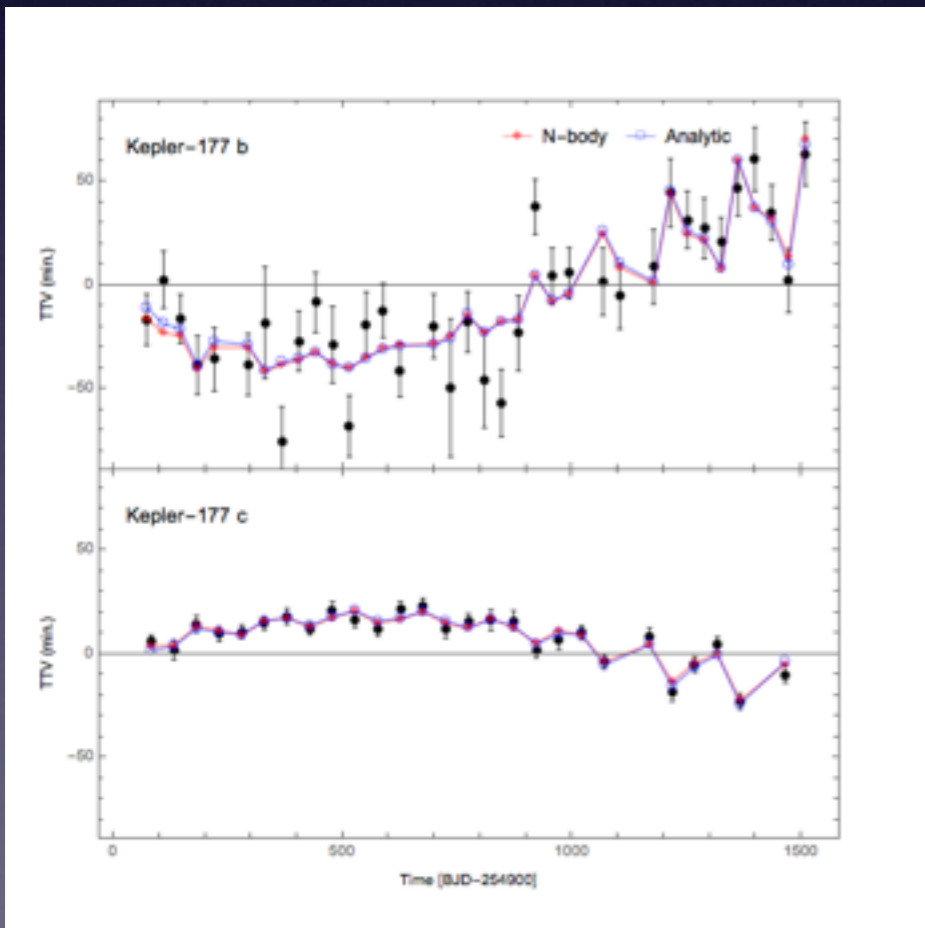
Solving the Inverse Problem: Markov Chain Monte Carlo

1. Generate an initial set

2.

3.

4.



Planet Masses From TTV

