



# Multi-technique investigation of the binary fraction among A-F type candidate hybrid variable stars discovered by Kepler

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## Multiplicity among the A/F type hybrid candidates

Lore Vermeyley

# Radial Velocity

- Hermes echelle spectroscopy
- Doppler shift
- Average of 10 bins between 415-570 nm
- Uncertainties: standard deviation

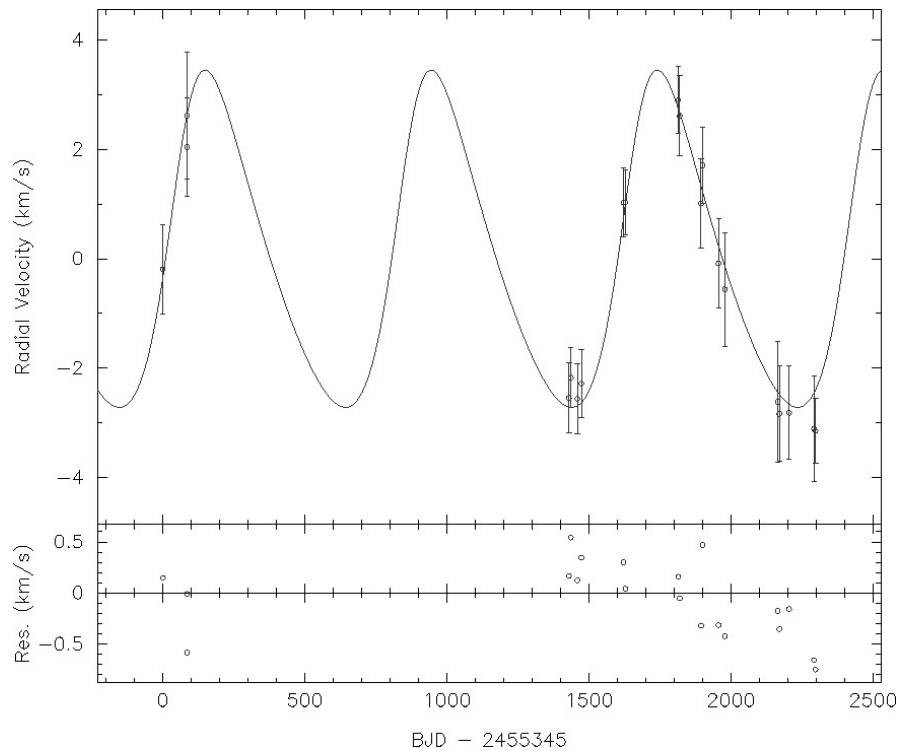
$$RV(t) = \frac{2\pi a \sin i}{P\sqrt{1-e^2}} [\cos(\nu + \omega) + e \cos \omega]$$

# Time Delay

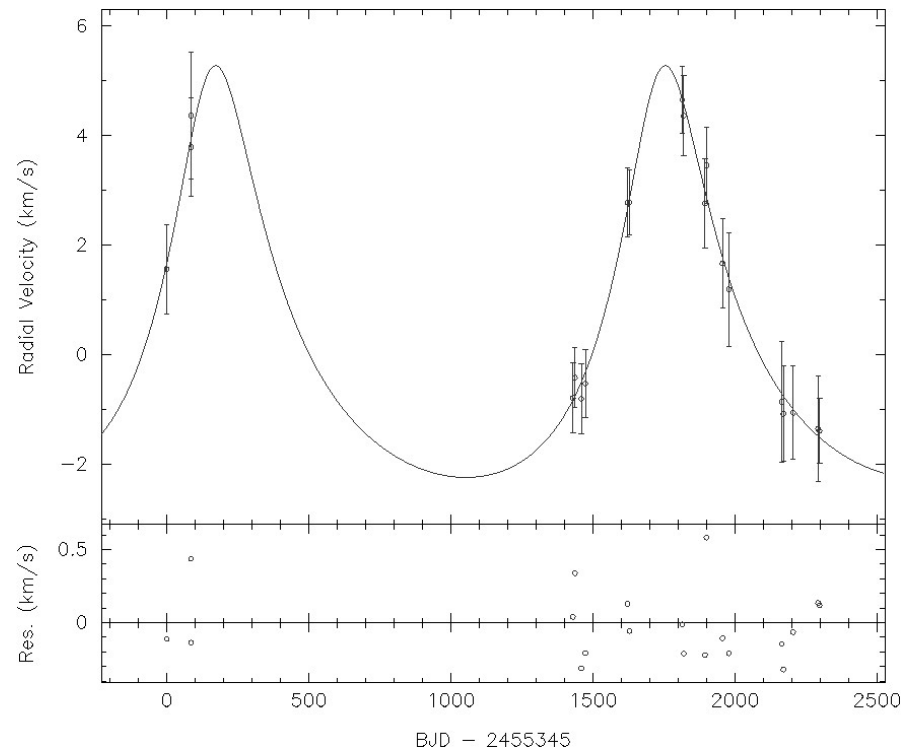
- Kepler photometry
- Light travel time effect
- Phase modulation  $\Delta\varphi$  in delta scuti pulsations
- $TD(t) = \frac{\Delta\varphi}{2\pi\nu}$
- 10 day bins

$$TD(t) = \frac{a \sin i}{c} \frac{1 - e^2}{1 + e \cos \nu} \sin(\nu + \omega)$$

# KIC 8975515: binary star

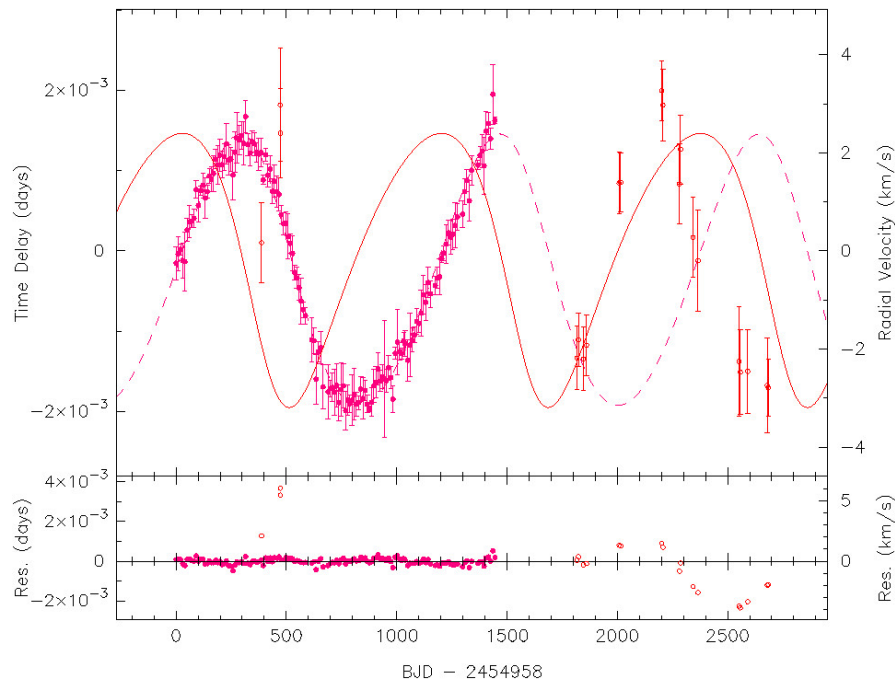


**Solution 1:**  
 $P = 796$  days  
 $e = 0.22$   
 $a_1 \sin i = 0.22$  AU



**Solution 2:**  
 $P = 1582$  days  
 $e = 0.41$   
 $a_1 \sin i = 0.50$  AU

# KIC 8975515: binary star

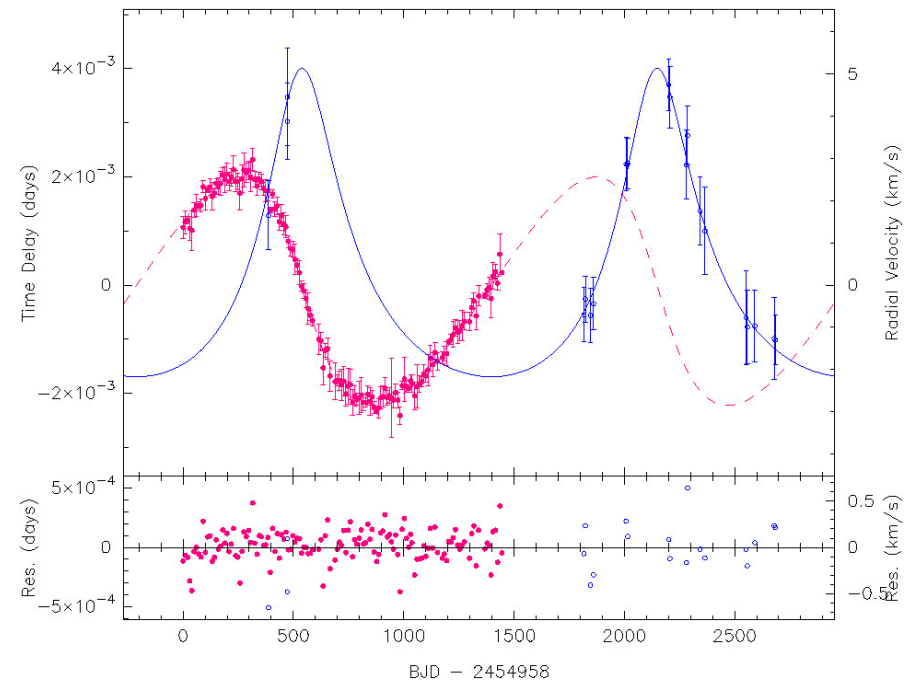


**Solution 1:**

$P = 1174$  days

$e = 0.20$

$a_1 \sin i = 0.296$  AU



**Solution 2:**

$P = 1609$  days

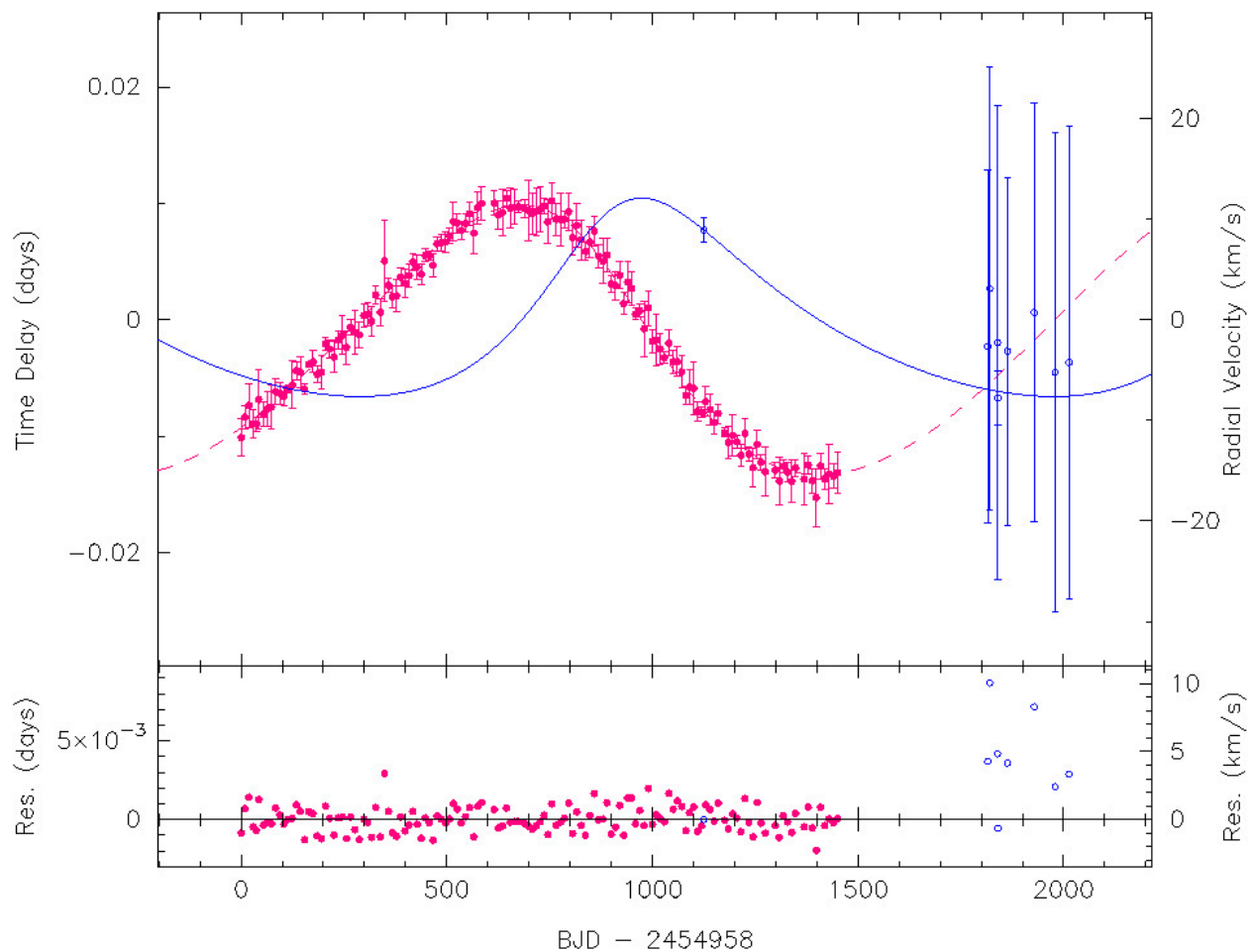
$e = 0.41$

$a_1 \sin i = 0.400$  AU

$a_2 \sin i = 0.49$  AU

$M_2/M_1 = 0.81$

# KIC 9650390 ( $v \sin i = 270$ km/s)



LAMOST radial velocities with small errors

# Conclusions

Advantages of combining RV and TD:

- Longer time base
- More accurate orbital parameters
- Identifying pulsating component
- Mass ratio

Thank you! Questions?