Dickinson

# Short Period Eclipsing Binaries in the Field of the Young Cluster NGC 2362

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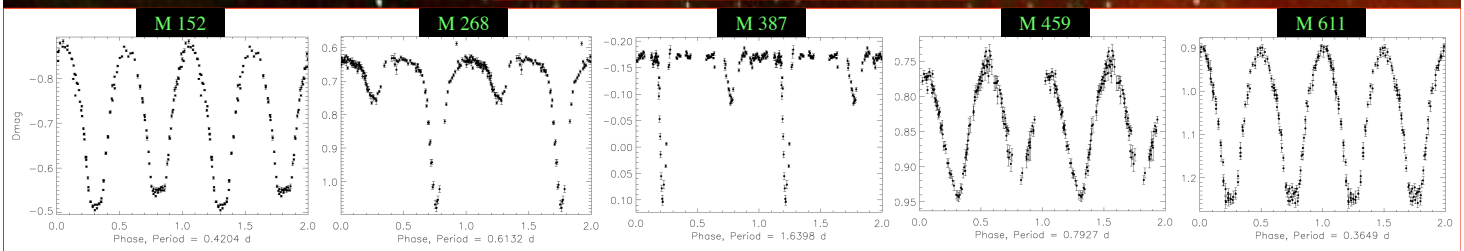
## ABSTRACT

In a study of rotation periods in the young ($t \sim 5$ Myr) cluster NGC 2362 (Hamilton et al. 2009), several new eclipsing systems were discovered. In this poster, we present photometric observations of these systems and separate them into likely eclipsing binaries and interesting puzzles. The binaries are most likely field stars and are not a part of the cluster.


## The Data

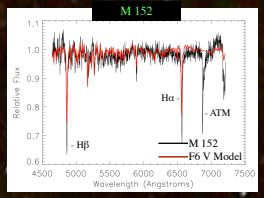
These systems were discovered with data taken in 2006 from observations made with the 0.8-m telescope at McDonald Observatory in the *I*-band between 18-25 January. In an effort to confirm the possible pre-main sequence nature of these systems, we obtained *UBVRI*-band photometry using the 1.0-m telescope at CTIO in February 2012 and constructed our own color-magnitude diagram for this cluster. Spectra were taken with the 4-m Blanco + HYDRA spectrograph at CTIO in February 2012.

## Suspected Eclipsing Binaries




## M 152

- No colors were obtained for this system as it was located just outside the field of view.

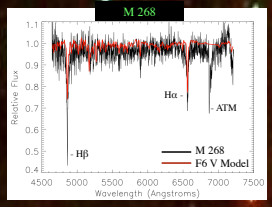



- Low-resolution spectra indicate a late F-type star.
- Cross-correlation with an F6 V template produces a radial velocity of (88 ± 5) km/s.

## M 268

| V | R | I | B-V | R-I | V-I |
|---|---|---|---|---|---|
| 14.833 | 14.541 | 14.258 | 0.458 | 0.271 | 0.575 |

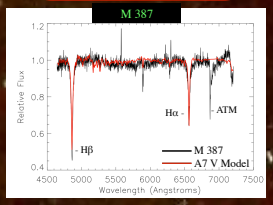
- Colors indicate a late F-type star, which is in agreement with the low-resolution spectrum shown below.
- Cross-correlation with an F6 V template produces a radial velocity of (45 ± 5) km/s.




## M 387

| V | R | I | B-V | R-I | V-I |
|---|---|---|---|---|---|
| 14.423 | 14.211 | 13.879 | 0.264 | 0.242 | 0.544 |

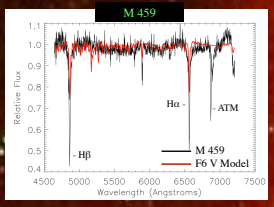
- Colors indicate a late A-type star, which is in agreement with the low-resolution spectrum shown below. However, the *V-I* color is significantly redder than what is expected for a late A star.
- Cross-correlation with an A7 V template produces a radial velocity of (28 ± 5) km/s.




## M 459

| V | R | I | B-V | R-I | V-I |
|---|---|---|---|---|---|
| 14.833 | 14.614 | 14.280 | 0.406 | 0.273 | 0.553 |

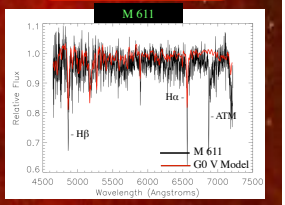
- Colors indicate a late F-type star, which is in agreement with the low-resolution spectrum shown below.
- Cross-correlation with an F6 V template produces a radial velocity of (81 ± 5) km/s.
- A second spectrum was obtained ~ 4 hours later, and a radial velocity of (54 ± 5) km/s was calculated.



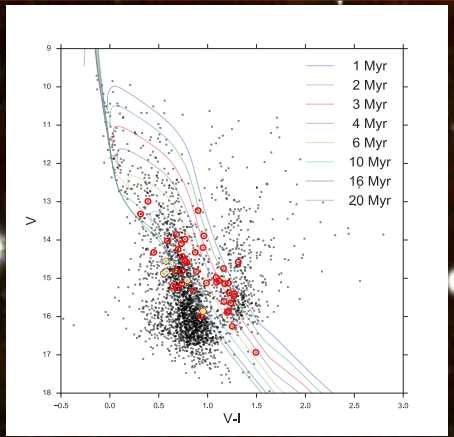

## M 611

| V | R | I | B-V | R-I | V-I |
|---|---|---|---|---|---|
| 15.061 | 14.753 | 14.270 | 0.588 | 0.467 | 0.791 |

- Colors indicate an early G-type star, which is in agreement with the low-resolution spectrum shown below. However, the *V-I* color is redder than what is expected for an early G star.
- Cross-correlation with a G0 V template produces a radial velocity of (53 ± 5) km/s.




## Color-Magnitude Diagram

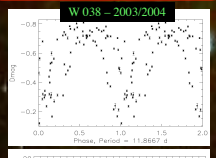


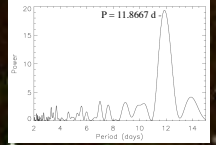

- This color-magnitude diagram of NGC 2362 was produced with data we obtained in February 2012. A subset of our 95 rotators is shown with open red circles. Stars M 268, M 387, M 459, and M 611 are identified with green dots. Star W 038 (discussed to the right) is identified with a yellow dot. The isochrones come from a new set of models called MIST (Choi et al. 2016).
- The eclipsing systems fall below the 20 Myr isochrone. The individual stars in these systems are even fainter than the single star sequence, suggesting that these objects are even older than 20 Myr. This would suggest that these eclipsing systems are even less likely to be in the cluster.

## W 038 – 2003/2004

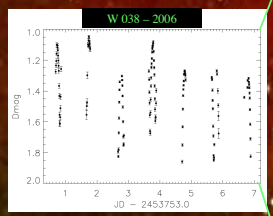
| V | R | I | B-V | R-I | V-I |
|---|---|---|---|---|---|
| 15.858 | 15.398 | 14.905 | 0.816 | 0.483 | 0.953 |

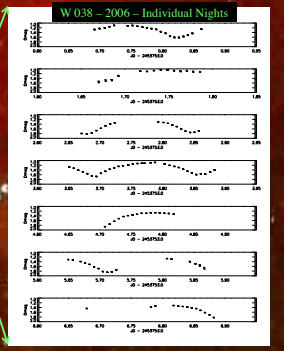
- In 2003/2004, we observed NGC 2362 once a night with the 0.82-m automated telescope at Tenagra Observatory from Dec - Mar.
- W038 was determined to have a period of 11.8667 d and had an interesting light curve with some sort of a phase shift.



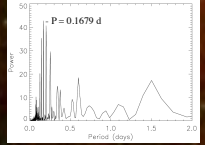

## An Interesting Puzzle…

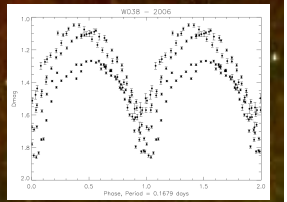



## W 038 in 2006

- In 2006, W038 varied over the course of ~5 hr.
- A periodogram analysis shows a peak at 0.1679 d.




Conclusions: We have found some very interesting eclipsing systems in the field of the young cluster NGC 2362; many more than are presented here. A radial velocity study of the objects in this poster is planned for January 2017. We will also model these systems with BinaryMaker 3.0 and continue to monitor the cluster in the future.

References: Choi, J., et al., 2016, ApJ, 823, 102.
Hamilton, C. M., et al., 2009, ASP Conference Proceeding, No. 1094, p. 361-364, 2009.

The background picture was taken from NASA/JPL-Caltech/Harvard-Smithsonian CfA