

## OBSERVING $\zeta$ GEMINORUM AS A HIGH SCHOOL PHYSICS PROJECT

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### Abstract

$\zeta$  Geminorum, a Cepheid variable, was observed for 35 days as a high school physics project. The shape, amplitude, and time of maximum of the phase curve are in excellent agreement with predictions.

### 1. Introduction

Cepheid pulsating variables, such as  $\zeta$  Gem, play an important role in distance determination in the universe, and in probing stellar evolution. Many of these stars can be observed visually with the unaided eye or with binoculars. Observation and analysis of variable stars is an excellent activity for students, because they can develop and integrate a wide range of math, science, and computing skills, while experiencing the excitement of doing real science with real data (Carlson 1992; Percy 1993; Mattei *et al.* 1994). One of us (AMR) observed  $\zeta$  Gem for 35 days, and analyzed the results as a project in a grade 12 physics course.

### 2. Observations

Observations of  $\zeta$  Gem were made with binoculars from a site in the city of Toronto, using the chart published by Percy (1993). The comparison stars and their adopted magnitudes were:  $\delta$  (3.5),  $\lambda$  (3.6), and  $\nu$  (4.2). The light curve is shown in Figure 1. The observations have been deposited in the AAVSO International Database.

### 3. Analysis

According to Szabados (1991), the maxima of  $\zeta$  Gem are given by  $t = 2443785.438 + (10.150074 - 10.76 \times 10^{-7} E)E$ , and a maximum occurs on JD 2450007.231. Szabados' period has been used to construct the phase diagram shown in Figure 2. This phase diagram shows a magnitude range of 3.7 to 4.2, a more rapid rise than decline, and a maximum which falls at phase 0.0 (to within the accuracy of the determination, which is about  $\pm 0.1$ ). The star's behavior is thus in accord with previous results and predictions.

### 4. Conclusions

This paper shows that variable star observing and analysis is a viable activity for

high school students, even within a large city. The results demonstrate the essential features of the star's behavior, while providing a hands-on introduction to scientific research.

### References

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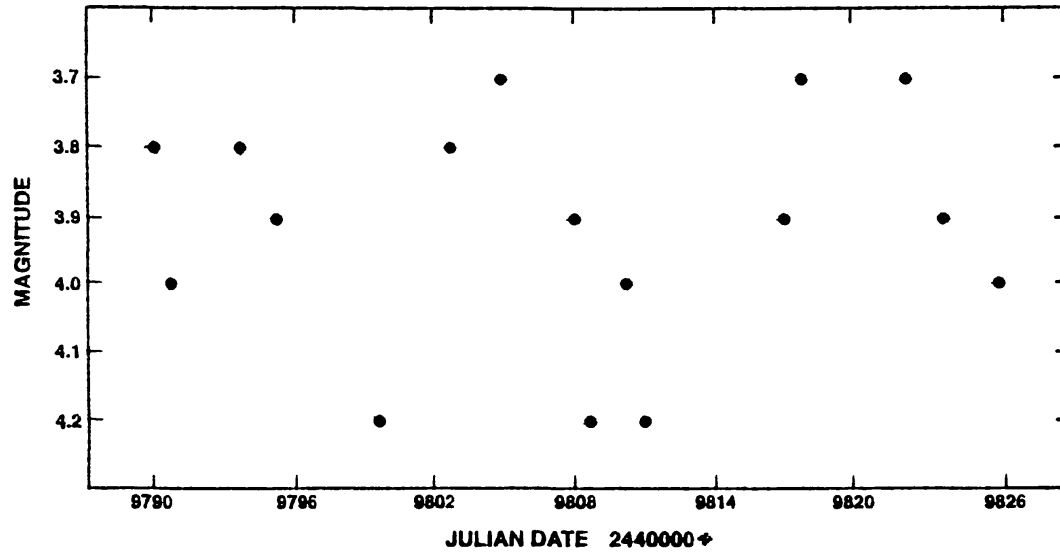


Figure 1. Visual light curve of  $\zeta$  Gem.

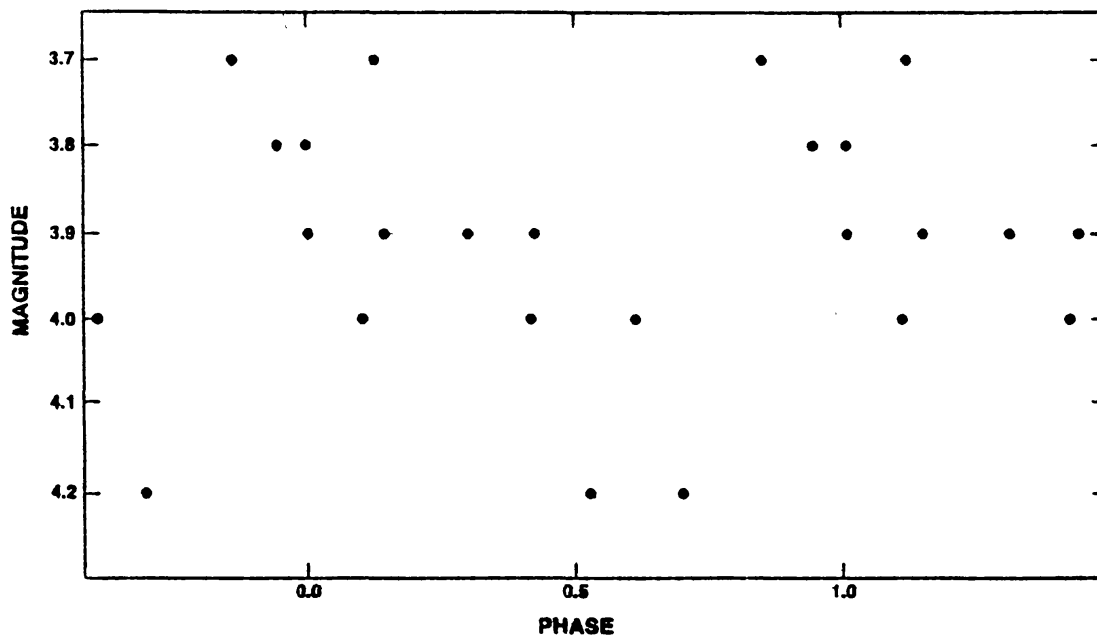


Figure 2. Phase diagram of  $\zeta$  Gem, using the ephemeris of Szabados (see text).