

New Times of Minimum Light of the Interacting Binary Star U Cephei

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ABSTRACT:

The well-studied interacting binary star system U Cephei has been neglected over the past couple decades. Its latest published ephemeris and observed-minus-calculated (O-C) analysis are over 15 years old. We observed U Cep in the Fall of 2009 using a robotic 16-inch Ritchey-Crétien telescope located at the Tzec Maun Observatory in New Mexico. Our observations include an entire primary eclipse consisting of over six consecutive hours of data. A few additional times of minimum light in 2008 and 2009 have been reported to the American Association of Variable Star Observers (AAVSO). We combine our newest time of primary minimum with the AAVSO data and others in the available literature to perform an O-C analysis and determine average rates of period change and mass transfer since 1980.

The latest O-C analysis of U Cep was published in 1995 by Kiss, *et al.*, and is shown in Fig.1. The plot contains quality data taken between 1980 and 1995 and was fit with a linear function. Selim and Demircan (1999) performed an analysis containing much older data from 1880 to 1995. Fig.2 displays their plot.

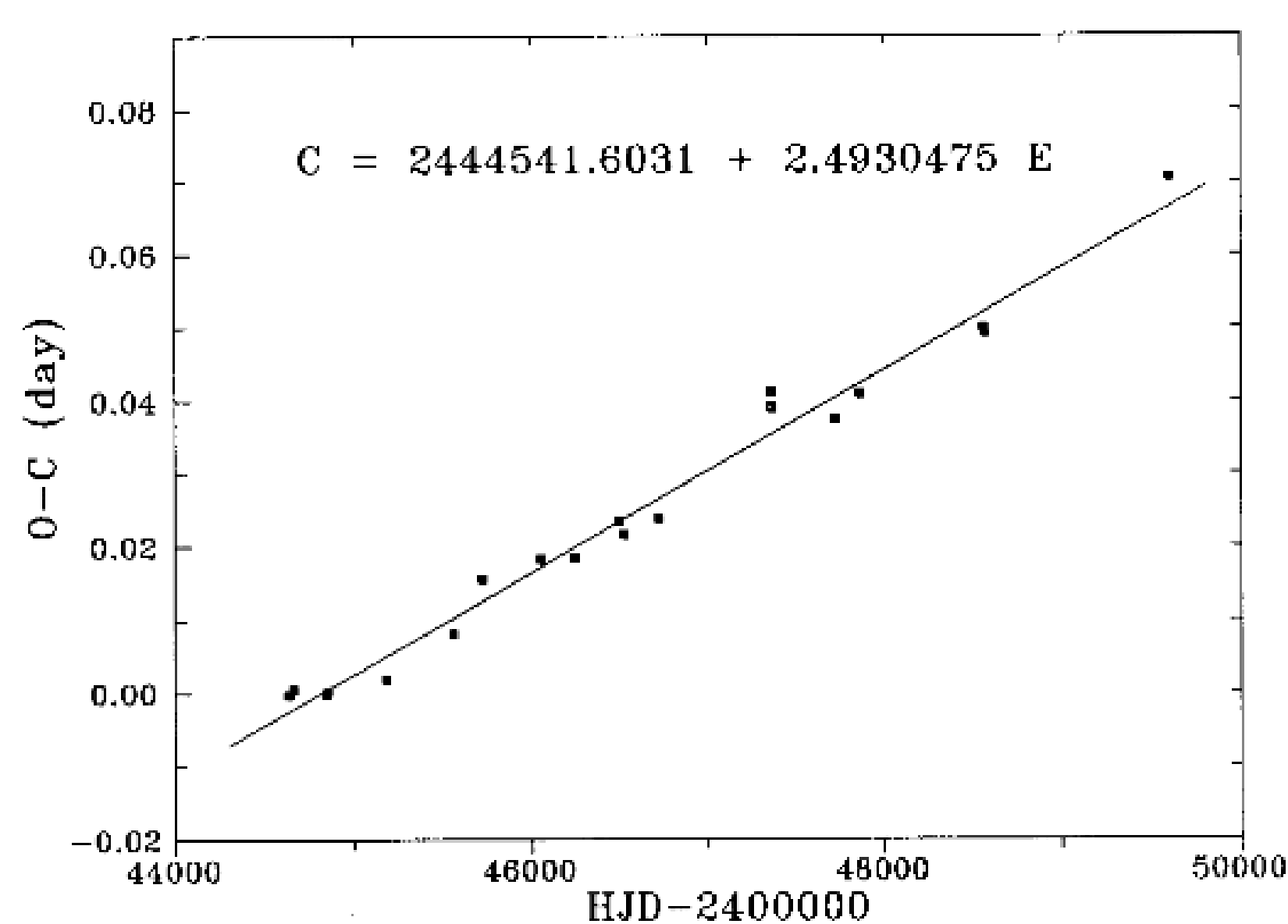


Fig. 1: The O-C plot by Kiss, *et al.* (1995). Data ranges from 1980 to 1995.

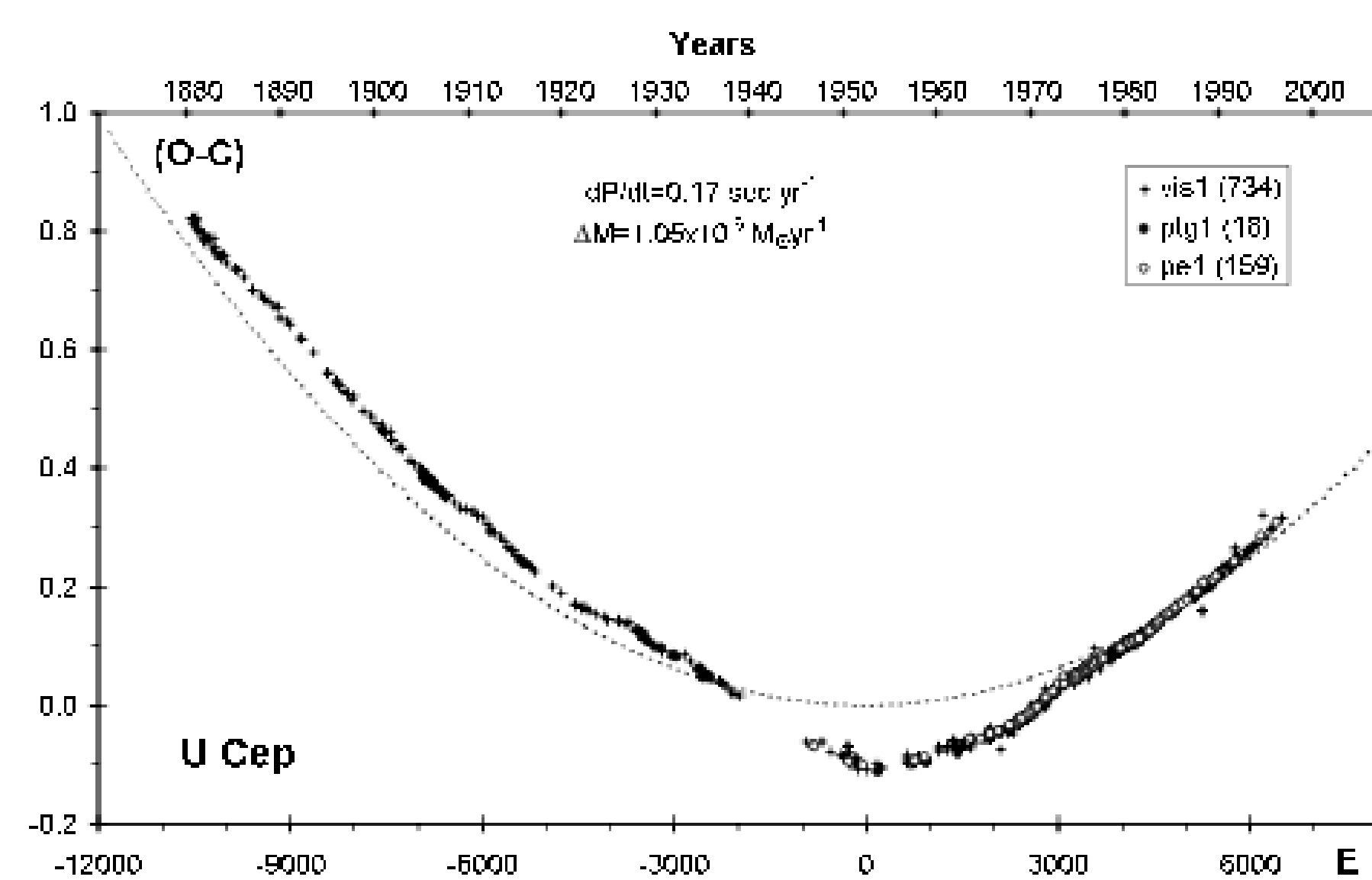


Fig. 2: The O-C plot by Selam & Demircan (1999). Data ranges from 1880 to 1995.

Using the masses reported by McCluskey, *et al.* (1988) of $m_1=4.2M_\odot$ and $m_2=2.8M_\odot$, we can calculate a conservative mass transfer rate:

$$\dot{m} = \frac{\dot{P} m_1 m_2}{3P(m_1 - m_2)} = \frac{(2.2 \times 10^{-9})(4.2)(2.8)}{3(2.493)(4.2 - 2.8)} = 2.47 \times 10^{-9} \frac{M_\odot}{\text{day}}$$

$$\dot{m} = 9.02 \times 10^{-7} \frac{M_\odot}{\text{year}}$$

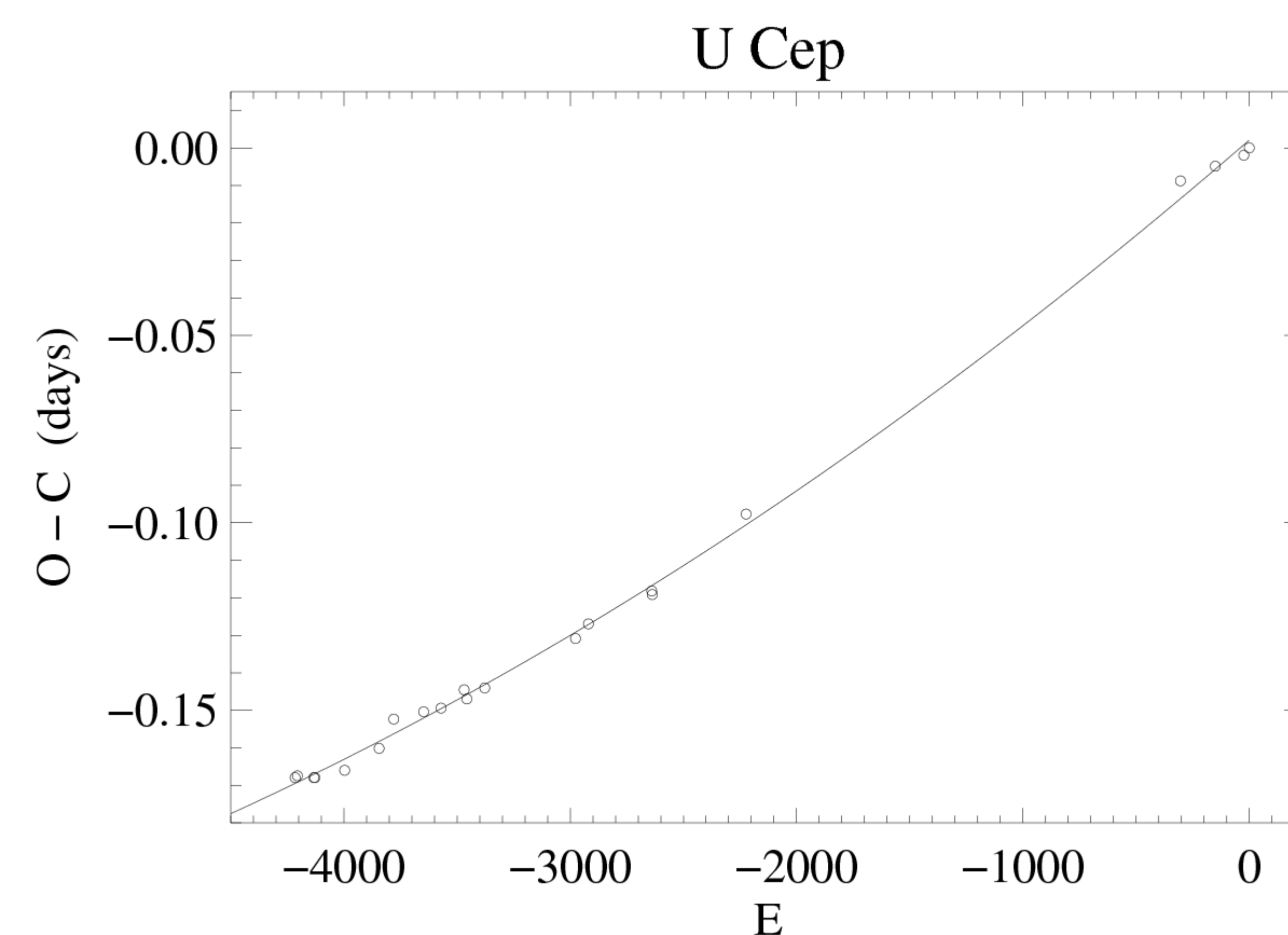


Fig. 4: O-C curve, using the following ephemeris:

$$\text{HJD}_{\text{Pr.Min.}} = 2455144.703 + 2.4930475 E$$

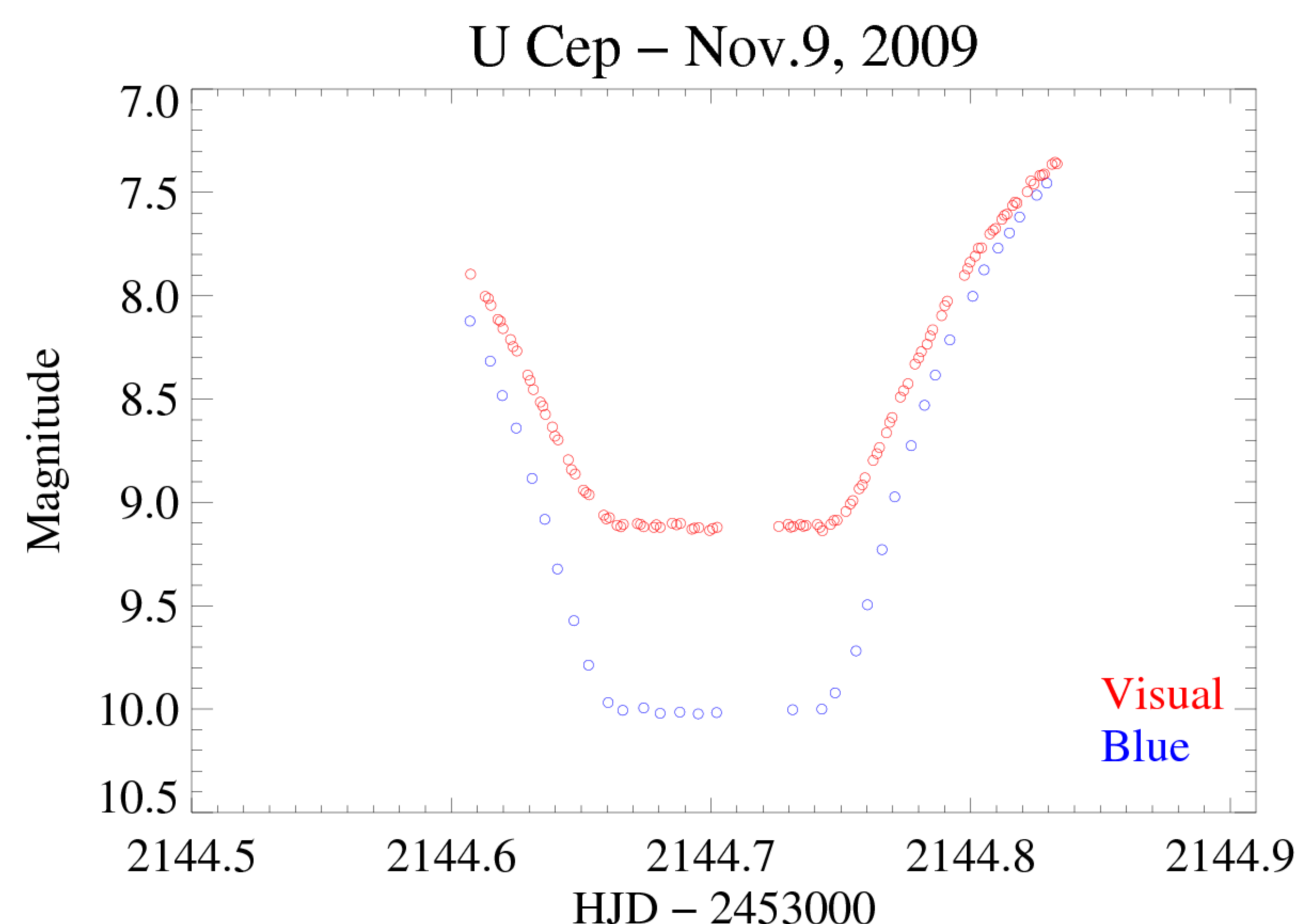


Fig. 3: The primary eclipse observed on Nov. 9, 2009. By the method of Kwee & van Woerden (1956), we calculated the time of primary minimum to be $\text{HJD } 2455144.703 \pm 0.002$.

We added our newest primary eclipse, shown in Fig. 3, and those reported to AAVSO by Samolyk (2008, 2009, & 2010) in our analysis. Our best-fit O-C curve is parabolic, as shown in Fig. 4.

The fit to our O-C curve is given by the following function:

$$O - C = (2.09 \times 10^{-3}) + (5.22 \times 10^{-5}) E + (2.74 \times 10^{-9}) E^2$$

which indicates a real period change over the 30-year span of the observations. The coefficient of the quadratic term, c_2 , yields the rate of period change.

$$c_2 = \frac{1}{2} P \dot{P}$$

$$\dot{P} = \frac{2c_2}{P} = \frac{2(2.74 \times 10^{-9})}{2.493} = 2.2 \times 10^{-9} \frac{\text{days}}{\text{day}}$$

CONCLUSION

We observed U Cep after 15 years of neglect and were able to detect a true period change over the last 30 years. This period change indicates a rather high rate of mass transfer that is consistent with an actively interacting Algol-type binary system.

The residuals of our O-C curve show possible cyclic oscillations in the period. Such oscillations could indicate the presence of a 3rd body in the system, magnetic activity cycles in a component of the system, or other secular changes. We will continue to observe eclipses of U Cep to further study its O-C curve and its variations.

ACKNOWLEDGEMENTS

We thank the Tzec Maun Foundation for the use of their remotely controlled robotic research-grade telescope systems.



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