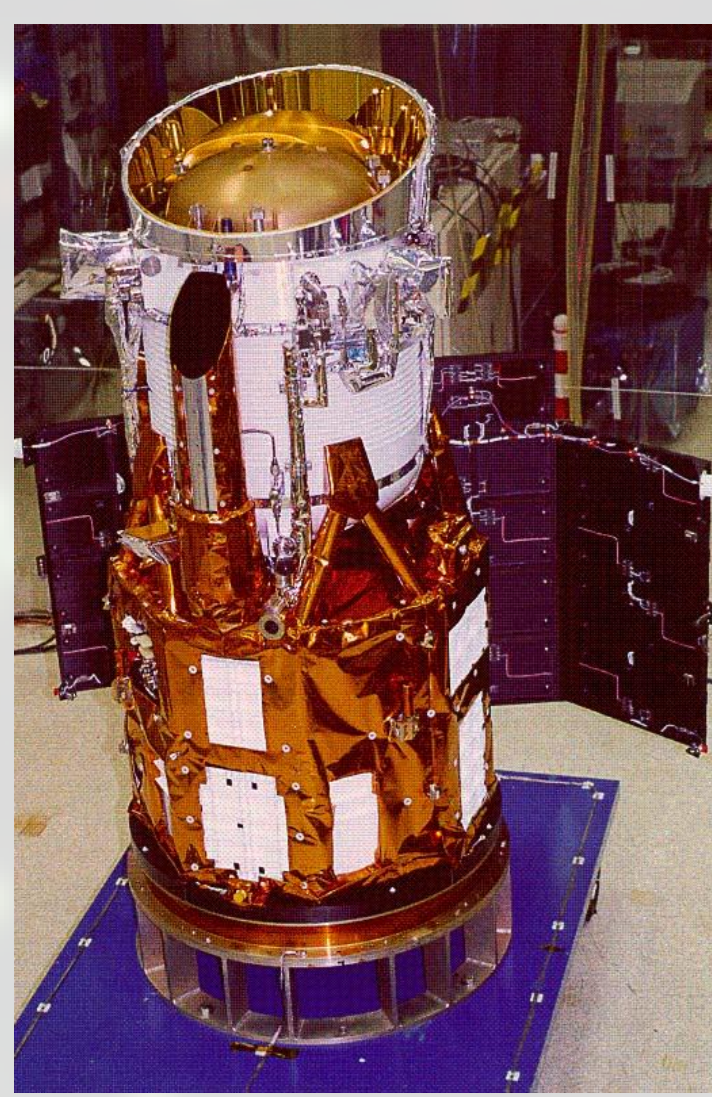


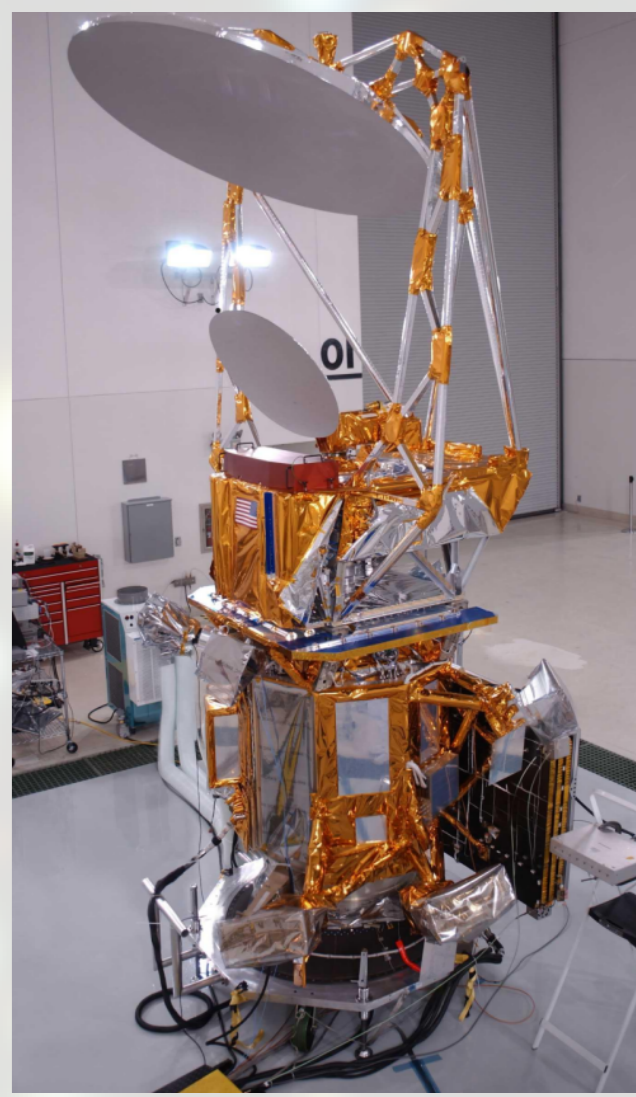
Eclipsing Binary Stars from Space

Hans Bruntt¹ & John Southworth²

(1) School of Physics, University of Sydney, Australia – hans@bruntt.dk
 (2) Department of Physics, University of Warwick, UK – jkt@astro.keele.ac.uk



WIRE



CORIOLIS

Observations. We have begun a programme to obtain high-precision photometry of bright detached eclipsing binary stars (dEBs) with the Wide field InfraRed Explorer (WIRE) satellite. The CCD camera on the 52mm star tracker collects two images every second, and after averaging data points collected within 75s the precision is 1 mmag per data point for bright stars ($V = 4$). Due to the small aperture of WIRE only stars brighter than $V = 6$ can be observed. We are collecting data for about a dozen dEB targets and here we present preliminary results for three of them. We have chosen dEBs with primary components of B and early A type. One of our aims is to combine the information from the light curve analyses of the eclipses with asteroseismic information from the analysis of the pulsation of the primary component.

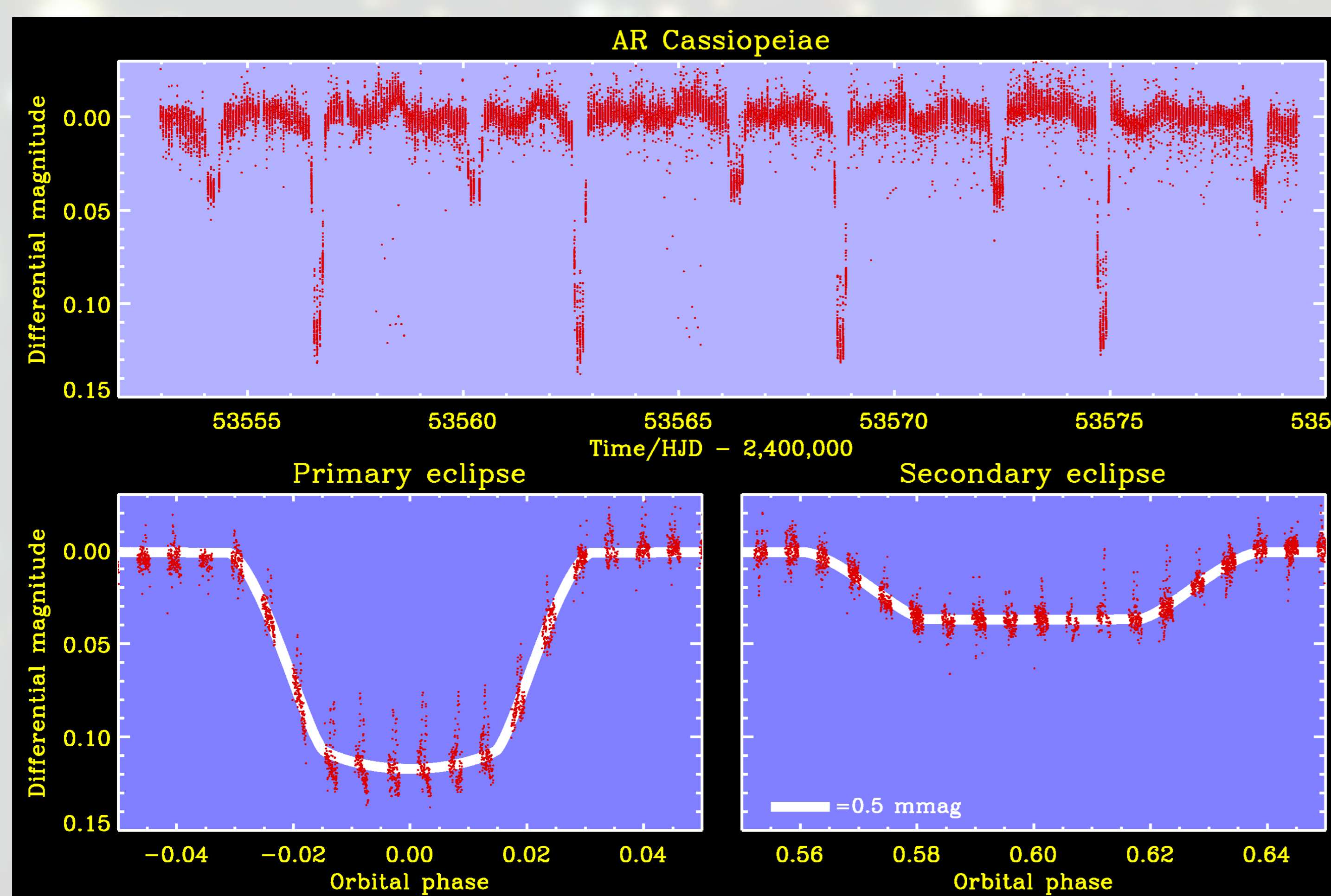
Targets. ψ Cen has a long orbital period, while AR Cas and β Aur have shallow eclipses. This has made observations with ground-based telescopes difficult. ψ Cen and AR Cas have secondary components which have much smaller masses and radii than the primary stars so the eclipses are total. This allows us to determine the radii with increased accuracy compared to β Aur which has partial eclipses. We are collecting new spectroscopic data for all systems, and so we will be able to provide strict constraints on the predictions of theoretical models. The basic properties of the dEB systems we present here are given in Table A below and their light curves are shown in Figs. 1–3.

Table A. Properties of the targets \triangleright Spectral type, magnitude, and period.

	ψ Cen	AR Cas	β Aur
Spectral type	A0 IV	B4 IV	A2 IV
V	4.0	4.9	1.9
Period [d]	38.813	6.066	3.960

Figure 1. ψ Centauri (right) \triangleright The light curve from WIRE is shown in the top panel (red points). Serendipity led to the discovery that ψ Cen is a dEB as it was observed as a secondary target for θ Cen. We used photometry with a time baseline of two years from SMEI (yellow points in top panel) on the Coriolis satellite to determine the period of 38.813d. The details of the primary and secondary eclipse are shown in the two bottom panels. The white curve is the best-fitting model light curve. We have made a detailed analysis of the light curve in Bruntt et al., astro-ph/0606551. From Monte Carlo simulations we find that the fractional radii of the two stars are determined to unprecedented accuracies of 0.1% and 0.2% (random errors). ψ Cen is an interesting system since its brightest component is located in the region of the Hertzsprung-Russell diagram between the blue edge of the instability strip and the region of g -mode oscillations seen in slowly pulsating B stars. In the Fourier spectrum we detect two low-frequency modes that we interpret as global oscillation g -modes in the primary star.

Figure 2. AR Cassiopeiae (below) \triangleright The light curve from WIRE is shown in the top panel and the details of the primary and secondary eclipses are shown in the bottom panels. This is a preliminary result and systematic instrumental effects have not yet been fully removed. However, intrinsic variations in brightness are clearly present. Fourier analysis of the time series after subtracting the best-fitting light curve solution shows the presence of several pulsation modes with periods from 0.5 to 2.0 days. In addition, there is a brightness modulation at the rotational period of the primary component, which could be due to surface inhomogeneities in this star. The spectral type of AR Cas is B4 IV + A6 V and the brightness variations are possibly due to SPB-type pulsation in the primary star.



Background. The study of detached eclipsing binaries is of fundamental importance to stellar astronomy as a way of measuring accurately the parameters of normal stars from basic observational data (Andersen 1991). The masses and radii of detached eclipsing binary (dEB) stars can be measured to accuracies better than 1%, and the effective temperatures and luminosities can be obtained from spectral analysis or the use of photometric calibrations. An important use of these data is in the calibration of theoretical models of stellar evolution, particularly if the component stars are of quite different mass or evolutionary stage. The importance of the physical effects included in theoretical models, eg. the extent of convective core overshooting and the efficiency of convective energy transport, need to be constrained by observations to increase the predictive power of the models. This may be done by measuring increasingly accurate absolute properties of dEBs, which requires much improved observational data. It is arguably more difficult to significantly improve the quality and quantity of light curves, rather than radial velocity curves, because of the large amount of telescope time needed for each system. The KEPLER and COROT space missions will help to solve this problem in the future by obtaining accurate and extensive light curves of a significant number of dEBs. The results presented here from the WIRE satellite give an indication of the level of accuracy that future space missions will provide.

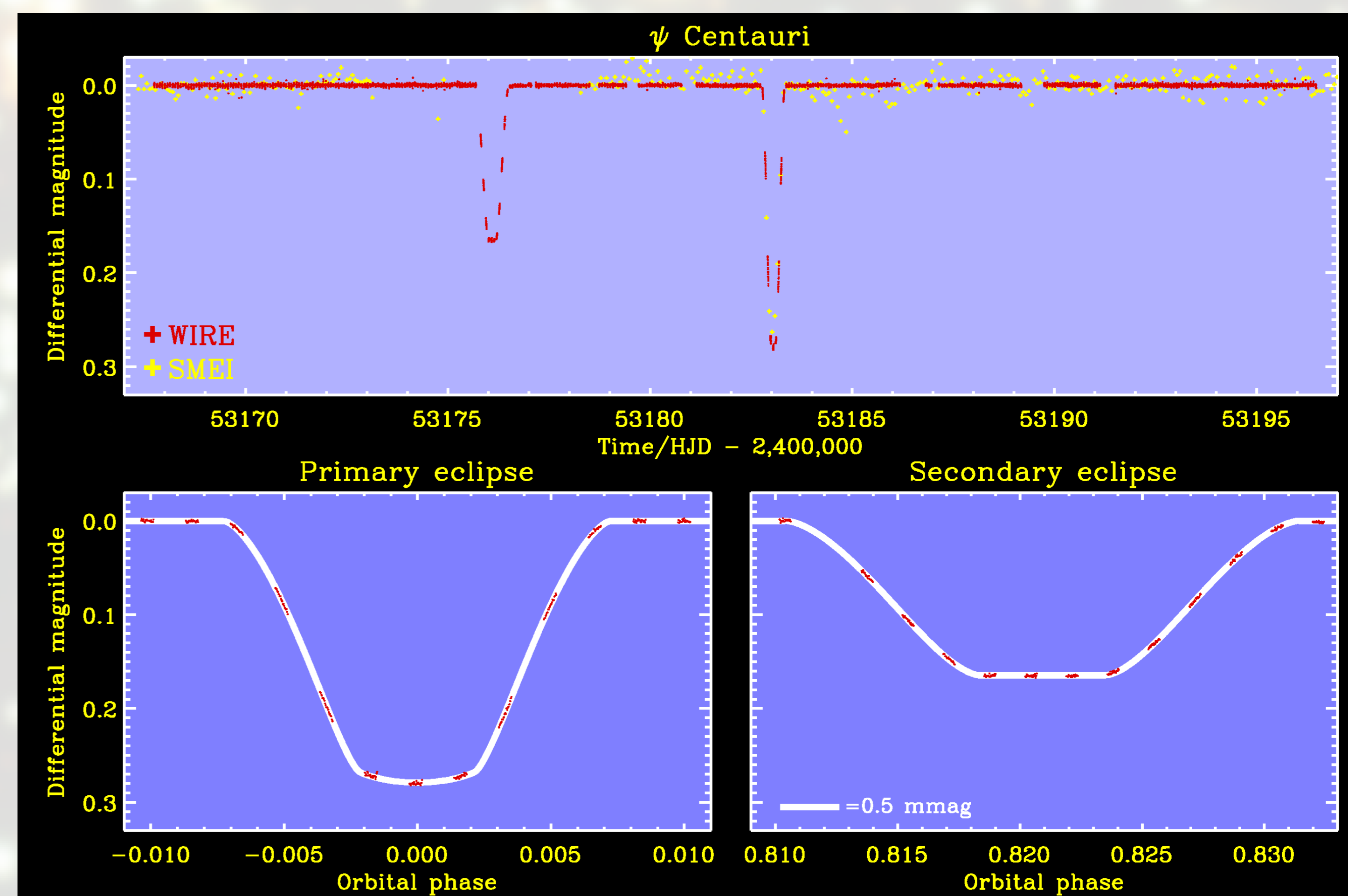
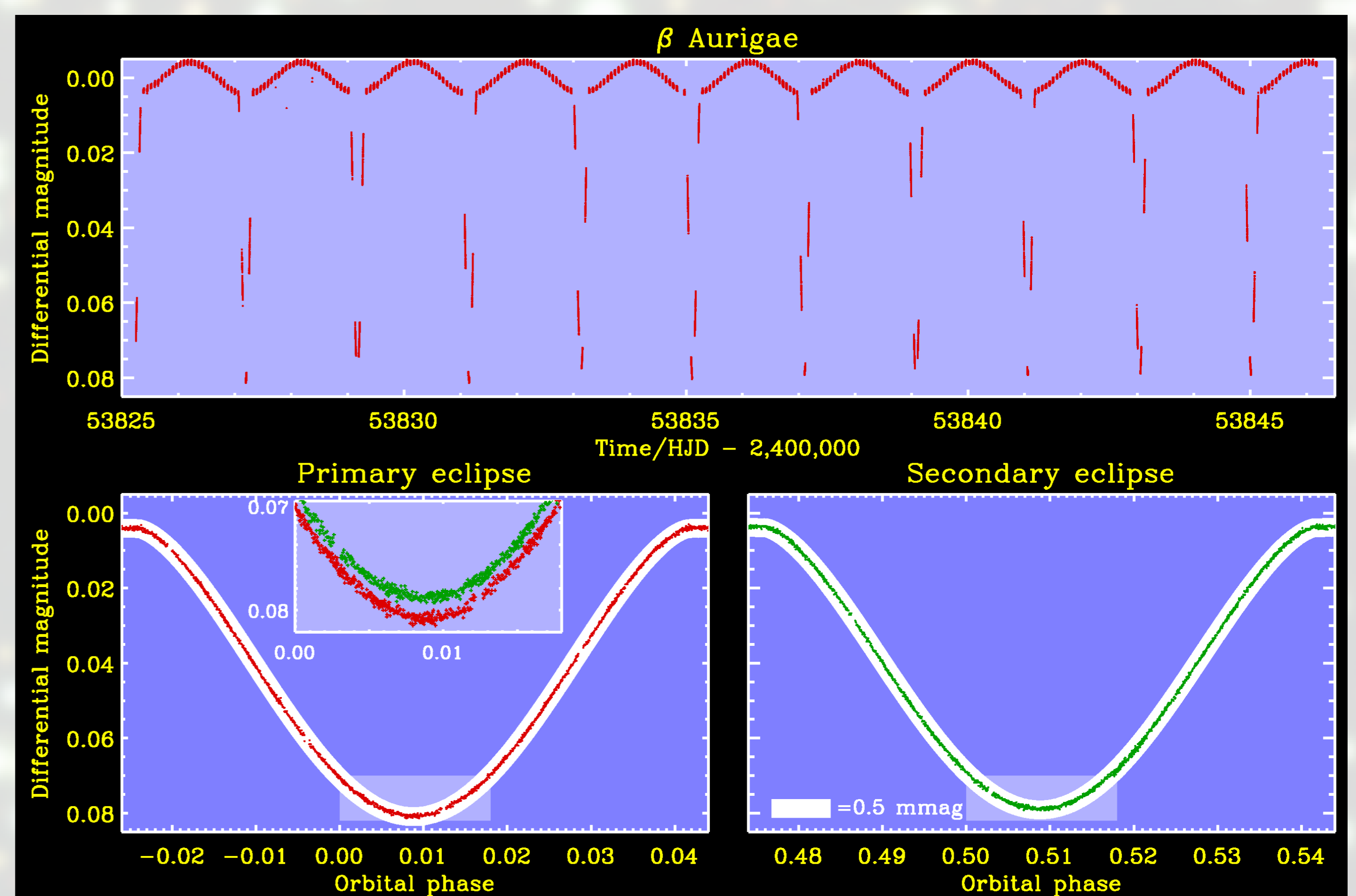


Figure 3. β Aurigae (below) \triangleright The light curve from WIRE has only been obtained very recently, and shows 11 eclipses over a time span of 21 days (top panel). Details of the eclipses, along with a preliminary light curve model, are shown in the bottom panels. The inset in the bottom left panel shows the slightly different depths of the primary (red) and secondary (green) eclipses.



Acknowledgments \triangleright We thank Derek L. Buzasi (and the WIRE team), Jens Viggo Clausen, Guillermo Torres, Alan Penny (and the CORIOLIS & SMEI teams), Terry Moon, John Innis, Donald W. Kurtz, Thebe Medupe, Francois van Wyk, and Gerald Handler for providing valuable input and making this project possible.