Highlights of Astronomy, Volume 15
XXVIIth IAU General Assembly, August 2009
Ian F Corbett, ed.

doi:10.1017/S1743921310009798

Times-Series Photometry & Spectroscopy of the Bright Blue Supergiant Rigel: Probing the Atmosphere and Interior of a SN II Progenitor

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As the 7th brightest star and the most luminous star in the solar neighborhood, Rigel (β Orionis) is a very intriguing object. This blue supergiant (B8 Iab; V-mag = +0.05–0.18-mag; B–V = −0.03), at a distance (from Hipparcos) of ∼240±35 pc has a $\langle M_V \rangle = -6.7$ mag. The following physical properties were determined via spectroscopic, photometric, and interferometric studies: $L/L_\odot \approx 66{,}000$ K; $T_{eff} \approx 12{,}000$ K; $M/M_\odot \approx 17\pm3$; $R/R_\odot \approx 70$; $\tau \approx 3$–10 Myr. Interestingly Rigel has similar physical properties with the 12th mag blue supergiant progenitor of SN 1987A: Sanduleak −69° 202a. Thus Rigel (along with its co-asterism Betelgeuse) are likely to be the nearest progenitors of a Type II supernova. Such a nearby explosion would be V ≈ −11th mag (similar to a quarter moon).

Intensive photometric observations were carried out using telescopes in Pennsylvania and Arizona. High resolution & high S/N spectroscopy was carried out by Eaton using the TSU 2.0 m Automatic Spectroscopic Telescope (AST) during 2008/09. Together, they show complex light and RV variations on times scales of hours, weeks, and months. Systematic RV variations of up to 10 km/s and light changes of up to 0.12-mag were found on similar timescales. Preliminary analyses of these data have been carried out for periodicities using FFT and CLEAN-est routines.

Evidence of cyclic/periodic oscillations are present in some of the datasets, in addition to stochastic variations. These observations have been carried out in preparation of continuous, ultra-high precision photometry planned with the Canadian MOST satellite for nearly one month during November/December, 2009. Our preliminary study indicates that Rigel will be an excellent target for asterioseismic studies with MOST and as well as the upcoming BRITE-Constellation Mission. The continuous ultra-high precision photometry from space expected from MOST will yield important information on the possible presence of p- and g- mode oscillations in this star. The study of these will permit Rigel's internal structure to be probed and compared to stellar interior models. After the frequencies and spacing are identified they will be compared to various modern interior models of evolved stars that match Rigel's measured physical properties.

Keywords. stars: atmospheres, early-type, evolution, fundamental parameters, individual (Rigel), oscillations, supernovae: general, variables: other

Acknowledgements

We acknowledge support for this research from NSF/RUI Grant AST05-07536 and NASA/ MOST Grant NNX09AH28G. The photometry from Pennsylvania was conducted by R. Wasatonic.