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Strong Shear and High-Amplitude Activity Cycle in a Metal-Rich Solar Analogue

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Abstract. Over an 11-year cycle the Sun changes its brightness by less than 0.1%. However, it is an open question how strong the Sun's photometric variability was in the distant past. One way to answer that is to study other Sun-like stars and compare their photometric variability with that of the Sun. In a recent paper, we presented ground-based spectroscopic observations of a 7.4-year cycle in the solar analogue HD 173701. Complemented with observations from the *Kepler* space telescope, those data constitute the most complete set of observations of a stellar cycle ever obtained for any Sun-like star. They reveal that HD 173701 has strong solar-like differential rotation and a magnetic cycle comparable to the cycle generated by the solar dynamo, but with a resulting variability twice the amplitude of that observed in the Sun.

Keywords. Sun: activity – techniques: photometric.

1. Introduction

Over the last few decades a number of studies has used observations of Sun-like stars to constrain information about possible historical variability in the Sun's photometry on time-scales comparable to the solar cycle or longer; see Hall (2008) for a comprehensive review.

2. New Approach: First Attempt

Space missions that have long uninterrupted time-series offer a unique possibility for new research in this field. The reason is partly because much higher photometric precision can be obtained from space than from the ground, but also because the space-based observations allow a complementary asteroseismic analysis to be undertaken. That analysis not only enables the fundamental properties of the stars such as mass, radius, age, and depth of the convection zone to be measured with high precision; it also supports measurements of both mean and differential rotation, and investigations of the nature of the dynamo driving the cycles in these stars. A first attempt to achieve that was undertaken by Kiefer *et al.* (2017) for a selection of 24 solar-like main-sequence stars. However, as only space-based observations were available for the study, no truly Sun-like cycles were identified in any of the stars.

3. Pilot Study, and First Results

Karoff *et al.* (2018) were able to combine high-precision space-based photometric and asteroseismic observations by *Kepler* of the solar analogue HD 173701 with ground-based spectroscopic observations dating back to 1978. As a result, we were able to detect a 7.4-year cycle in the star, and we could also measure the amplitudes of the photometric variability, asteroseismic variability and changes in rotation rates that could be ascribed to differential rotation. The amplitudes were 2–5 times the solar values, and we argue that the reason was the higher metallicity of the star ([M/H] = 0.3).

4. Anticipating the Near Future

The study by Karoff *et al.* (2018) demonstrated the power of combining ground-based and space-based observations of Sun-like stars in order to understand the Sun's photometric variability in the distant past. Great advances are expected in this field in the near future when observations from the TESS mission (Ricker *et al.* 2015) become available. With those data we should be able to apply asteroseismology to measure the fundamental stellar parameters of most of the 100 or so stars that were observed from Mount Wilson Observatory and which are now being observed from Lowell Observatory; Hall (2008) gives a helpful discussion about those observations from Mount Wilson and Lowell observatories.

References

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