Pushing through the 1m/s Radial-Velocity barrier for a Maunder-Minimum star.

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In the hunt for Earth twins, which demands a radial-velocity (RV) precision of 10 cm/s, minimising the impact of stellar variability in RV measurements is a critical challenge. Since 2012, a dedicated programme has been deployed to use the high-resolution echelle spectrograph HARPS-N mounted on the Telescopio Nazionale Galileo to conduct a blind RV Search for Rocky Planets (RPS) around bright stars in the Northern Hemisphere (TNG). Here we present an extreme-precision RV study of HD166620, an RPS target with a Vmag of 6.28. Since the early 2000s, this star has been in a Grand Maunder Minimum state, which makes it an excellent target for low-mass planet searches with minimal effort needed to account for stellar variability. We use a novel wavelength domain technique called SCALPELS to correct for the long-term activity cycle and subtle long-term instrumental systematics, by correcting the effects of spectral line-shape changes on the radial velocity.

We modelled the system including a Gaussian Process regression together with decorrelation against SCALPELS basis functions, using the kima nested-sampling tool. The resulting posterior distributions suggest the presence of multiple planetary reflex-motion signals with amplitudes of order 50 cm/s detected with 4 to 5-sigma significance. The orbital periods of the candidate planets are of order days to months. Our analysis also revealed long-term instrumental zero-point drifts at the sub-m/s level. The impact of this long-term signal was minimised by obtaining and subtracting zero-point offsets between instrumental maintenance interventions, using an ensemble of standard-star observations. We found that these drifts had no significant impact on the candidate planet signals.

Our results demonstrate the effectiveness of combining wavelength-domain and time-domain activity mitigation in attaining a sub-m/s detection threshold at long orbital periods, and demonstrate the decade-timescale stability of HARPS-N at the 50 cm/s level. This will be of great importance in the upcoming PLATO science era.