

Characterization of the NIRPS Guiding Camera for Close Visual Binaries

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We use the NIRPS near-infrared guiding camera (C-RED 2) to characterise the detectability of close stellar companions and their contamination of the 0.4'' High-Accuracy science fibre as functions of angular separation and magnitude difference. The fibre is centred on the target (primary) star, while light from a nearby companion may also enter through its extended PSF wings (Fig. 1).

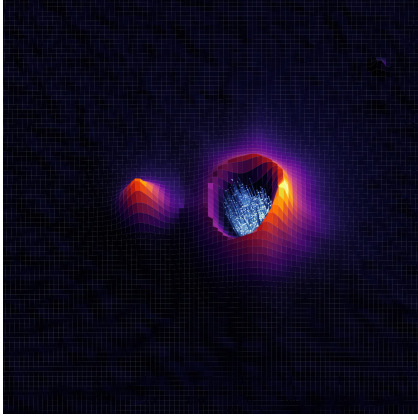


Figure 1: Visualisation of a binary system based on a real guiding-camera image, with a schematic fibre overlay centred on the primary.

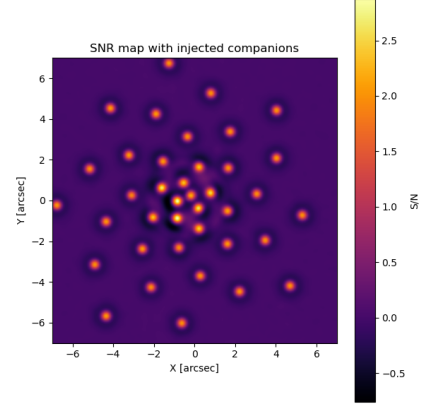


Figure 2: Injected companions after stellar-halo filtering.

PSF characterisation and filtering. The radial PSF measured by the guiding camera in fibre-offset images is fitted with two Moffat (1969) components: a core and halo with FWHM values of 0.26'' and 0.44''. To suppress the stellar halo and enhance faint companion signals, we adapt the filtering approach of Wahhaj et al. (2013): (1) broad Gaussian convolution, (2) halo subtraction, (3) narrow Gaussian convolution, (4) azimuthal subtraction, and (5) stripe correction.

Companion detectability.

1. **Noise-based contrast:** aperture-flux scatter in annuli gives the local noise, $\sigma(r)$, and the contrast limit $5\sigma(r)/F_\star$, with reference primary-star flux $F_\star$ measured in a fibre-offset image.
2. **Injection and recovery:** we inject synthetic companions (Fig. 2), rotate the injection pattern through 20 angles, and repeat filtering. We smooth the S/N map with a circular kernel and match peaks above the threshold to injected positions.

The limiting flux recovers 19/20 companions at each separation (95% completeness), giving a contrast curve close to the 5σ result (Fig. 3). Beyond approximately 2.5'', the limiting contrast reaches $\Delta m \simeq 9.6$ –9.8, corresponding to a guiding-camera limiting magnitude of approximately 13.5 for these observations.

Contamination. We shift and scale the primary-star PSF to estimate companion flux entering the science fibre, defining:

$$C_{\text{cont}}(r, \Delta m) = F_{\text{comp}}^{\text{fibre}}(r, \Delta m) / F_\star^{\text{fibre}}.$$

The dashed line in Fig. 4 shows the contamination at the guiding-camera detection limit. Companions above it are expected to be detected at 95% completeness, while those below may remain undetected yet still contaminate the science fibre, particularly at small separations.

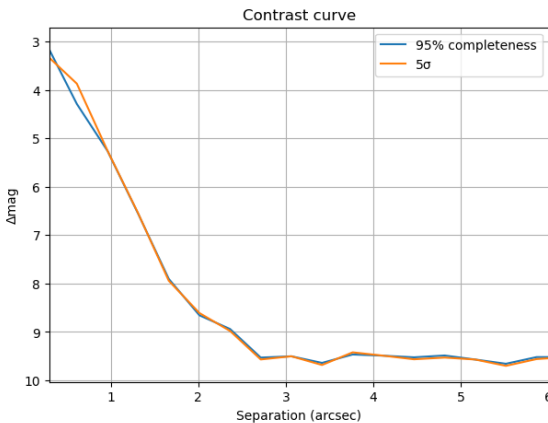


Figure 3: 95% completeness and 5σ contrast curves.

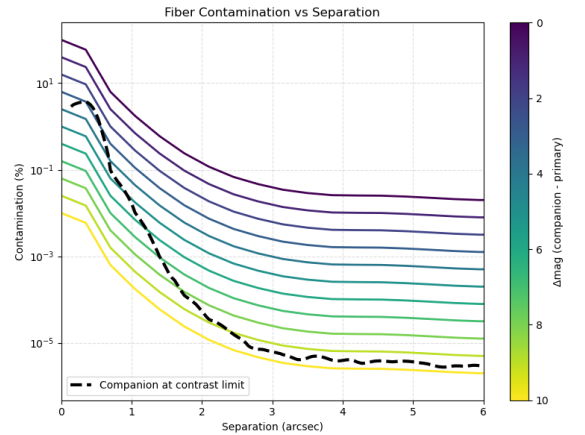


Figure 4: Contamination (%) versus separation. Colours indicate magnitude difference; the dashed line marks the converted detection limit.

Limitation: the analysis is based on observations of q Vel obtained during a single night. Contamination estimates assume that the companion PSF is adequately represented by the measured primary-star PSF.