

Catching WASP-1 b on the Transit Floor: Transit-Grade i' Photometry with a 17-inch Telescope and No Calibration Frames

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Abstract. We observed the hot-Jupiter host **WASP-1** ($V \approx 11.3$) for 98 minutes in Sloan i' with a 17-inch PlaneWave and an ASI6200MM camera (270×20 s), catching the star *during* a transit of its planet WASP-1 b. No dark, flat, or bias frames were available, and the frames carried no astrometric solution; we solved a reference frame from scratch against Gaia DR3³ (0.28" residual) and reduced the raw frames with ensemble differential photometry. The reduction reaches **5.6 mmag per 20 s frame** and ≈ 1.3 mmag in 5-minute bins on the $V \approx 11.3$ host — transit-grade precision. Because the run began after first contact and ended before egress, the light curve samples only the limb-darkened **transit floor**: it shows a shallow ($\sim 0.4\%$) curvature whose minimum falls at **3:39±20 min MST**, consistent with the predicted mid-transit (03:57)⁷. The absence of an out-of-transit baseline precludes an independent depth measurement. The astrometry and photometry are validated by cross-matching the field to VSX⁶: WASP-1 is recovered as the catalogued transiting planet ("EP"), an independent EW eclipsing binary in the same frames shows a coherent $\sim 10\%$ variation, and catalogued long-period variables are correctly flat over the short window.

1 Introduction

WASP-1 b was one of the first two planets discovered by the SuperWASP survey^{1,2} — an inflated hot Jupiter ($\sim 0.9 M_J$, $\sim 1.4 R_J$) in a 2.52-day orbit around an F7 star, producing a $\sim 1.24\%$ transit⁷. This note is a first test of whether our 17-inch imaging system and reduction pipeline — built for variable-star work — can reach the few-mmag precision that exoplanet transits demand, on a real transit and under deliberately adverse conditions (no calibration frames, no plate solution in the headers, and a run that caught only the interior of the transit).

2 Observations & data reduction

WASP-1 was imaged on 2026 July 11 from 02:31–04:09 MST (airmass $1.26 \rightarrow 1.05$, falling as the field rose), 270×20 s in Sloan i', unguided-drift held to ~ 2 px over the run. The telescope was not fitted with a rotator and the target was approximately centred; the NINA headers recorded the intended pointing but no WCS.

We detected bright stars in a reference frame and solved its WCS by matching to Gaia DR3³ — a rotation/scale/parity scan with translation recovered by offset-voting, refined to a 0.28" TAN solution on 46 stars. Star positions for WASP-1 (placed by catalogue coordinates) and 208 field stars ($G < 15.5$) were then projected into every frame; per-frame drift was tracked from bright stars and forced circular-aperture photometry ($r=14$ px, local sky annulus) was measured on memory-mapped cutouts. **No dark/flat/bias correction was applied.** Because the field is fixed on the detector (no dither, no meridian flip) and we use *ensemble differential* photometry against 24 nearby comparison stars, the flat-field and dark systematics are largely common-mode and divide out — the working principle behind observing transits without flats. Times are mid-exposure JD.

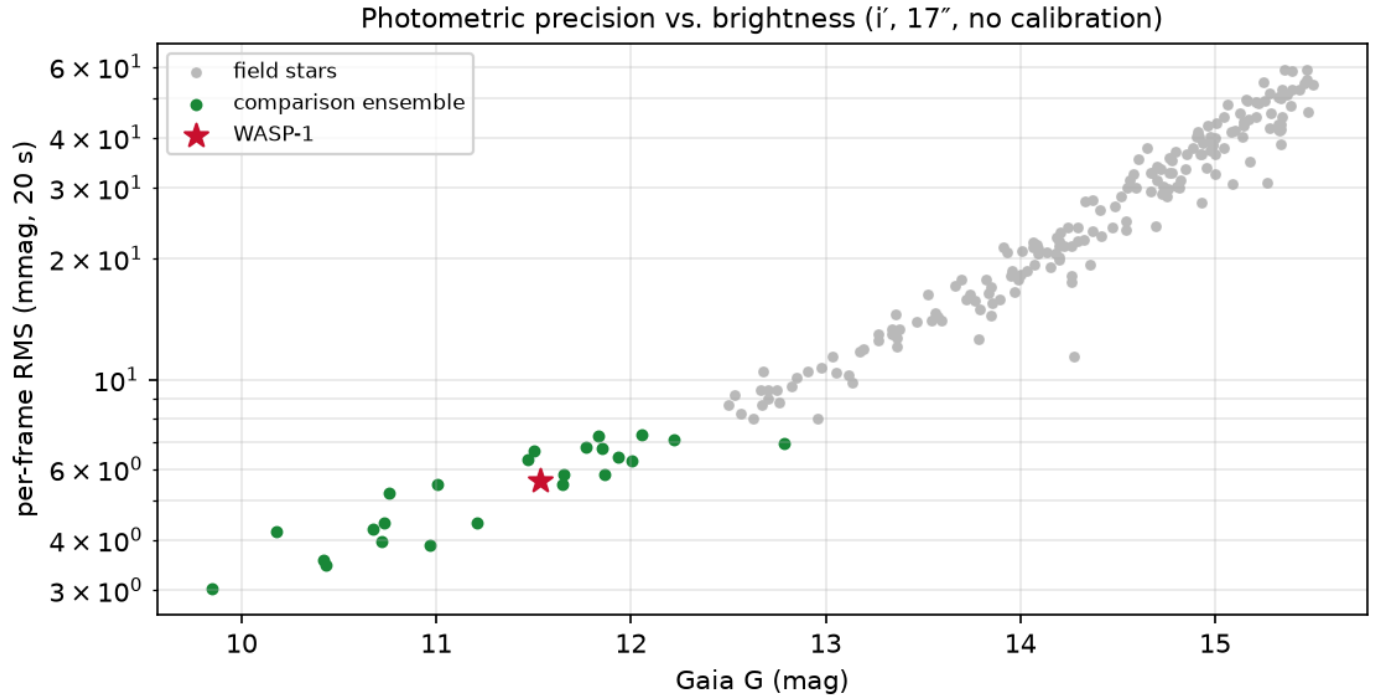


Figure 1. Per-frame RMS versus brightness. WASP-1 (star) sits on the noise floor with the comparison ensemble (green); faint field stars scatter up as photon noise grows. The floor is ~ 5 mmag per 20 s frame — set by scintillation and sky, not calibration residuals.

3 Results

Precision. The WASP-1 differential light curve scatters at 5.6 mmag per 20 s frame and ≈ 1.3 mmag in 5-minute bins (Figure 2) — comfortably below the ~ 13 mmag depth of a typical hot-Jupiter transit, and reached without any calibration frames.

The transit. First contact was at $\approx 02:05$ and egress at $\approx 05:48$, so the run lies entirely between the contacts: we recorded the interior *floor* of the transit rather than an ingress/egress. The light curve is a shallow bowl — the limb-darkened floor is faintest at mid-transit — with a parabolic minimum at **3:39 $\pm$ 20 min MST**, statistically consistent with the predicted mid-transit at 03:57^{7,8}, and it turns back up in the final bins. A monotonic airmass residual would not reverse; the minimum near mid, plus the upturn after, is the signature of the transit floor. Without an out-of-transit reference we do not fit an absolute depth.

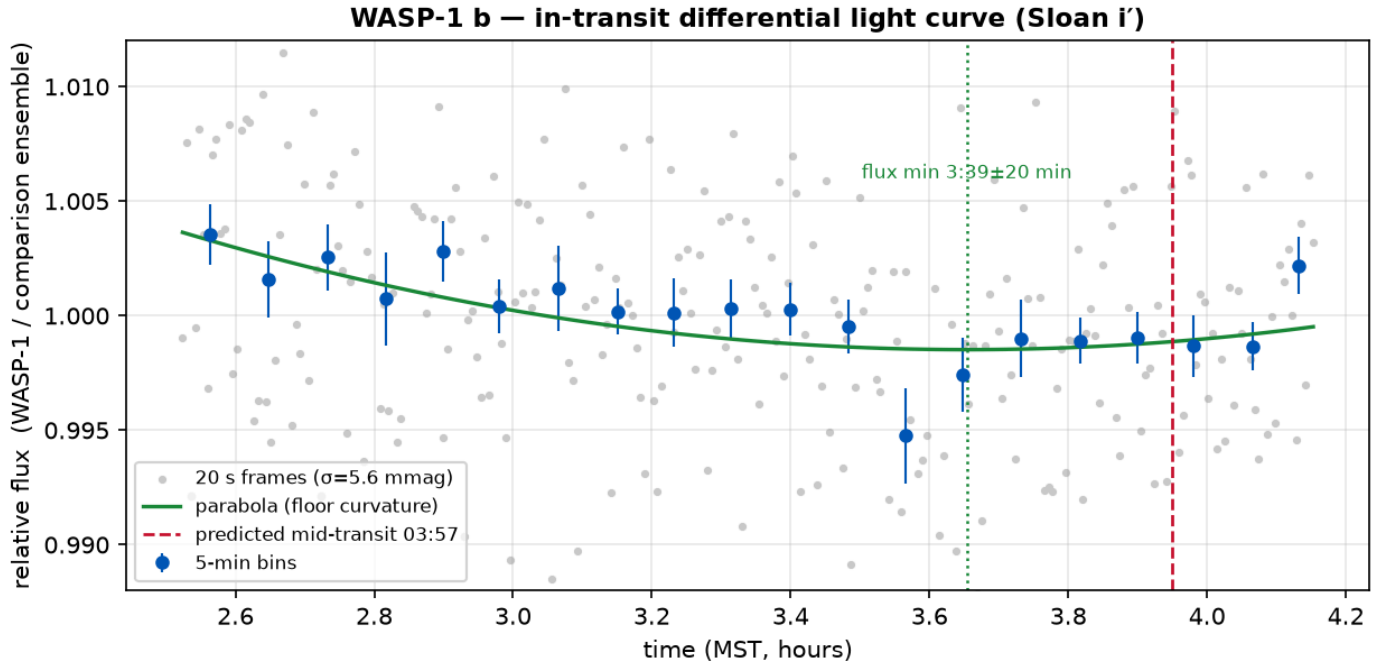


Figure 2. WASP-1 b differential light curve (i'). Grey: 20 s frames; blue: 5-min bins; green: parabolic fit to the floor curvature, minimising at 3:39 MST (dotted) against the predicted mid-transit (red dashed, 03:57). The run samples the interior of the transit; there is no out-of-transit baseline.

Validation. Cross-matching the field to VSX⁶ recovers 14 catalogued variables, including WASP-1 itself (type "EP", transiting planet) — an independent confirmation of the astrometric identification. An EW eclipsing binary in the same frames (Figure 3, right) shows a coherent $\sim 10\%$ brightening during the run, while catalogued rotational/RS-type variables (periods of days) are correctly flat over 98 minutes — the pipeline shows variability where expected and constancy where expected.

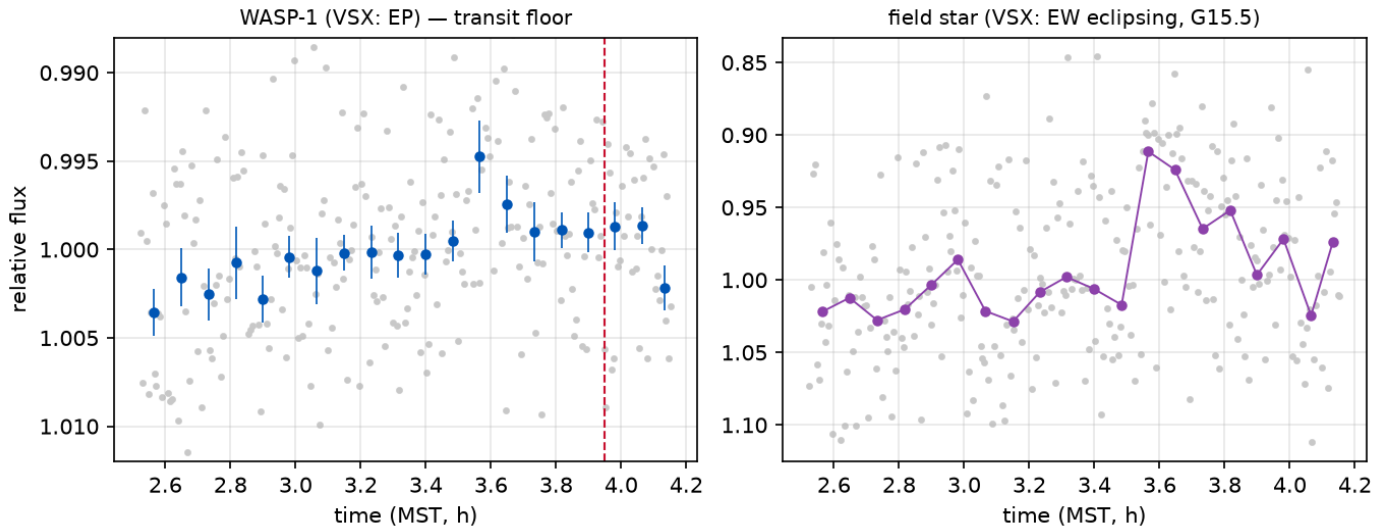


Figure 3. Left: WASP-1's transit-floor light curve. Right: an independent EW eclipsing binary in the same field, recovered showing a real $\sim 10\%$ variation — end-to-end validation of the from-scratch astrometry and photometry.

4 Discussion

The result is primarily methodological: on a $V \approx 11.3$ star, a 17-inch reaches ~ 5 mmag per 20 s and ~ 1 mmag binned with *no calibration frames and no header WCS*, by leaning on a fixed field and ensemble differential photometry. That is more than enough for hot-Jupiter transits. The scientific yield here was limited by timing, not sensitivity: the run began ~ 25 min after first contact and stopped before egress, so there is no out-of-transit baseline and hence no independent depth or precise timing — only the floor and its curvature. A residual second-order (colour)

extinction trend with airmass cannot be fully excluded, though the reversal of the light curve after mid-transit argues against a purely instrumental slope. The obvious improvements are to (i) start well before first contact and run through egress for a full, baseline-anchored light curve; (ii) take dusk/dawn sky flats and darks for absolute calibration; and (iii) select colour-matched comparison stars to suppress the airmass–colour term.

5 Conclusions

A 17-inch telescope and a variable-star pipeline, with no calibration frames and a from-scratch astrometric solution, delivered transit-grade *i'* photometry (5.6 mmag/frame) of WASP-1 during a transit of WASP-1 b. The captured transit floor minimises at the predicted mid-transit time, and the reduction is independently validated by recovering VSX variables — including WASP-1 itself and an EW eclipsing binary — from the same frames. The system is ready for exoplanet transits; the next attempt simply needs to bracket the full event.

References

- 1. Collier Cameron et al. 2007, MNRAS 375, 951.
- 2. Pollacco et al. 2006, PASP 118, 1407.
- 3. Gaia Collaboration 2023, A&A 674, A1.
- 4. Astropy Collaboration 2022, ApJ 935, 167.
- 5. Bradley et al., *photutils*.
- 6. Watson, Henden & Price, AAVSO International Variable Star Index (VSX).
- 7. NASA Exoplanet Archive (WASP-1 b parameters).
- 8. Mandel & Agol 2002, ApJ 580, L171.

Appendix A Observing log & reduction parameters

quantity	value
Target / host	WASP-1 (Gaia G=11.53; VSX type EP)
Instrument	PlaneWave 17" (2939 mm) + ASI6200MM, Sloan i'
Frames	270 × 20 s, 02:31–04:09 MST 2026-07-11
Calibration	none (no dark/flat/bias)
Astrometry	Gaia-DR3 solve, 0.28" residual (46 stars)
Field stars measured	208 (G<15.5); comparison ensemble 24
Aperture	r=14 px, sky annulus 22–30 px
Per-frame precision	5.6 mmag (WASP-1)
Flux minimum	3:39±20 min MST (predicted mid 03:57)
VSX variables recovered	14 (incl. WASP-1 EP, an EW binary)