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A search for the IRAS–AKARI Planet Nine candidate in the NOIRLab Source Catalog DR2

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ABSTRACT

Phan et al. (2025) paired a 1983 IRAS source with a 2006 AKARI source and proposed a planet at 500–700 au. The 2013–2018 track lies inside the Dark Energy Survey footprint. I searched the single-epoch measurements of the NOIRLab Source Catalog DR2 (245 DECam exposures on 92 nights) for any body on an orbit through both positions at 300–900 au, bound or unbound. No linkage of five or more nights exists. Injected bodies are recovered with 95 % efficiency to $r = 23.04$ and 50 % to $r = 23.34$. If the object is as large as its far-infrared fluxes imply and has an albedo of at least 0.10, the search would have found it with probability ≥ 0.87 out to 700 au; beyond that the answer depends on how the fluxes are fitted. Darker or strongly methane-absorbed bodies beyond about 500 au are not excluded.

THE CANDIDATE

Phan et al. (2025) searched the IRAS and AKARI far-infrared catalogues for pairs of sources that could be one slowly moving body, as expected for the planet proposed by Batygin & Brown (2016). One pair survived: IRAS F02211−4844 (scans from 1983 June 26 to September 1) and AKARI-MUSL J0220440−491247 (2006), separated by 47.′5. They infer 500–700 au and 7–17 $M_\oplus$.

Such a body crosses the Dark Energy Survey (DES) wide area. The DES search for outer Solar System objects (Bernardinelli et al. 2022) covered bound orbits at 29–2500 au with 50 % completeness at $r = 23.77$. Its catalogue has no object beyond 96 au and none within 3° of this field, so it already disfavours a bound, bright body. It predates the candidate, did not search unbound orbits, and no published work tests the candidate directly. Two-body orbits through the two positions are bound for only 32 % of the allowed cases, and for none beyond 700 au.

DATA AND METHOD

Data. All single-epoch measurements of the NOIRLab Source Catalog DR2 (Nidever et al. 2021) in $33.^\circ6 < \alpha < 36.^\circ4$, $-50.^\circ4 < \delta < -48.^\circ6$ were taken from Astro Data Lab: 3,239,738 measurements from 245 DECam exposures on 92 nights between 2013 September 13 and 2018 November 17.

Orbit family. Each member passes through both published positions. The IRAS epoch is uniform over its scan window; the AKARI epoch is 2006 June 26 or December 26, since scans on both dates are reported at one position. The positions are scattered by the IRAS error ellipse ($18'' \times 7''$) and by $15''$ for AKARI, for which no error is published. Barycentric distance in 2006 is uniform in 300–900 au and radial velocity in $\pm 2.5\,\mathrm{km\,s^{-1}}$. Bound and unbound solutions are kept.

Search. A measurement with neighbours within $1''$ on two other nights is static (97.6 %); 76,967 transients remain. A body at these distances moves at least $3''$ per day here and cannot veto itself. Transients are linked in 231 inverse-distance bins using the coordinates of Bernstein & Khushalani (2000), in which a family member moves on a straight line. A linkage is accepted with at least seven nights in at least two seasons, an arc of at least 180 days, $\chi^2/\nu \leq 4$ and an orbit inside the family. These criteria were fixed before the search.

Efficiency. 75,000 synthetic family members with solar colours and 12,000 with methane-like colours ($r - i = -0.8$, $r - z = -1.5$) were given detections according to each exposure's measured completeness for isolated DES DR2 point sources (Abbott et al. 2021), removed where blended with a static source, and passed through the same linker.

RESULTS

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The search gives 151 linkages. None has five or more nights. The longest have four nights; there are 40 of them, and 20–53 in each of six control searches (five with shuffled exposure epochs, one with the motion reversed). None of the 34 inside the family has consistent photometry. No control search gives a linkage of five or more nights.

As a control, the linker searched the fields of two catalogued DES objects, 2013 RV_{124} (45 au, $r = 22.45$) and 2014 ST_{373} (52 au, $r = 22.62$), in a box of the same size offset from the known orbit, with the two-body motion model and looser tolerances that these distances require. The best linkage of each contains all of its detections that pass the static veto (25 and 32; one each is lost to it) and no other. Shorter fragments of the same tracks were also accepted.

Figure 1 (left) shows the recovered fraction. For solar colours it is 1.00 for $r \leq 22.25$, 95 % at $r = 23.04$ and 50 % at $r = 23.34$; bound and unbound members agree within 0.04 mag. For methane-like colours the 95 % and 50 % levels are $r = 22.42$ and 23.30. The catalogue is the limit: on the same exposures its 50 % depth is 0.43–0.52 mag shallower than that of the DES pipeline.

WHAT THIS EXCLUDES

The far-infrared fluxes fix the size of the body, but not tightly: no single blackbody fits the 60, 90 and 100 μm fluxes to better than 20–40 %. Two fits of the same three points give 48 K with a radius of 2.9 $R_\oplus$ at 500 au, and 52 K with 2.4 $R_\oplus$; the radius scales with distance. In reflected sunlight the larger body has $r = 22.86$, 22.11 and 20.92 at 500 au for geometric albedos of 0.05, 0.10 and 0.30; the smaller one is 0.43 mag fainter. The model has no colour corrections and zero phase angle.

Figure 1 (right) gives the recovery probability at that brightness for both radii. For albedo 0.30 it is 1.00 at every distance. For albedo 0.10 it is ≥ 0.87 out to 700 au with either radius; at 700–800 au it is 0.96 with the larger radius and 0.31 with the smaller. For albedo 0.05 it is ≥ 0.91 inside 500 au, and 0.91 or 0.20 at 500–600 au.

The pair itself also argues against one body. At 500–700 au the parallax between the June and December AKARI scans is 10.′5–14.′8, and the motion during the 67 days of IRAS scans is 5.′0–6.′9, larger than the IRAS 60 μm beam; one catalogued position per mission is hard to reconcile with either. Every orbit through the two positions is inclined by 114–119°, against 16° ± 5° estimated for Planet Nine (Brown & Batygin 2021).

LIMITS

The search does not reach bodies fainter than $r \approx 23.3$: albedo $\lesssim 0.05$ beyond about 500 au with the infrared-implied size, or strong methane absorption. Injected position errors are Gaussian while real faint ones have heavier tails, so the depth may be optimistic by about 0.02 mag. The search does not cover distances outside 300–900 au, position errors larger than assumed, or other AKARI epochs. A pixel-level search of the same exposures, or Rubin Observatory data, would close the faint case.

This research uses services or data provided by the Astro Data Lab, which is part of the Community Science and Data Center Program of NSF NOIRLab, and ephemerides from JPL Horizons. Code, the injection records, all result tables and an independent review of the search are archived at doi:10.5281/zenodo.24245913. Use of AI tools: Claude (Anthropic; model Claude Fable 5.2, through Claude Code, 2026 November 11–15) searched the literature, wrote and ran all code, drew the figure and wrote the first draft. The author chose the question, approved each stage and is responsible for the content.

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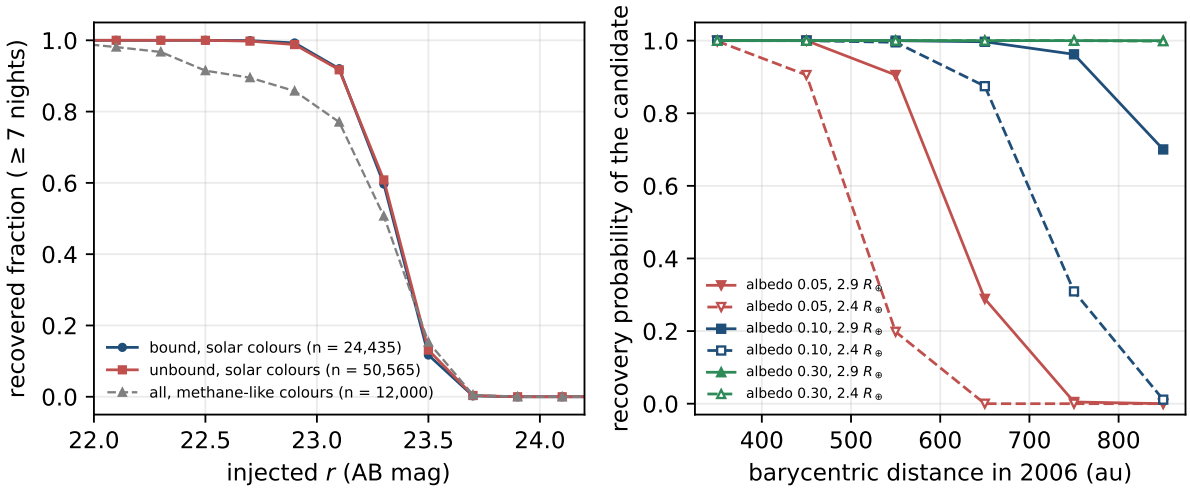


Figure 1. Left: fraction of injected bodies recovered on at least seven nights, in 0.2-mag bins. Right: recovery probability of a body with the size implied by the far-infrared fluxes, for three geometric albedos and two radius fits (radius at 500 au), in 100-au bins (solar colours).