AN ILLUSTRATED RESEARCH REPORT

Does a moving viewpoint change the exoplanet sky?

A moving observer. Moving stars. Changing opportunities.

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Finding Earth 2.0 | Independent researcher and simulation author

The question. As the Solar System moves through the Milky Way, could changing distances and sightlines make other planetary systems easier to detect? This report connects that curiosity to an interactive simulation and a limited, reproducible calculation. Both the observer and the target stars move; travelling farther does not by itself guarantee more discoveries.

01 / THE ORIGINAL IDEA

A: today. B: future.
C: later future.

These positions illustrate a changing viewpoint along a Galactic orbit. They are epochs of the same observer, not three different stars.

233 km/s

Adopted tangential speed.

0.0777 ly

Solar path in 100 years, at this speed: about 4,915 AU.

128,600

Approximate model years needed to travel 100 light-years.

The crucial distinction

Solar travel relative to the Galaxy differs from motion relative to a nearby star. The latter changes our view of that star's planets.

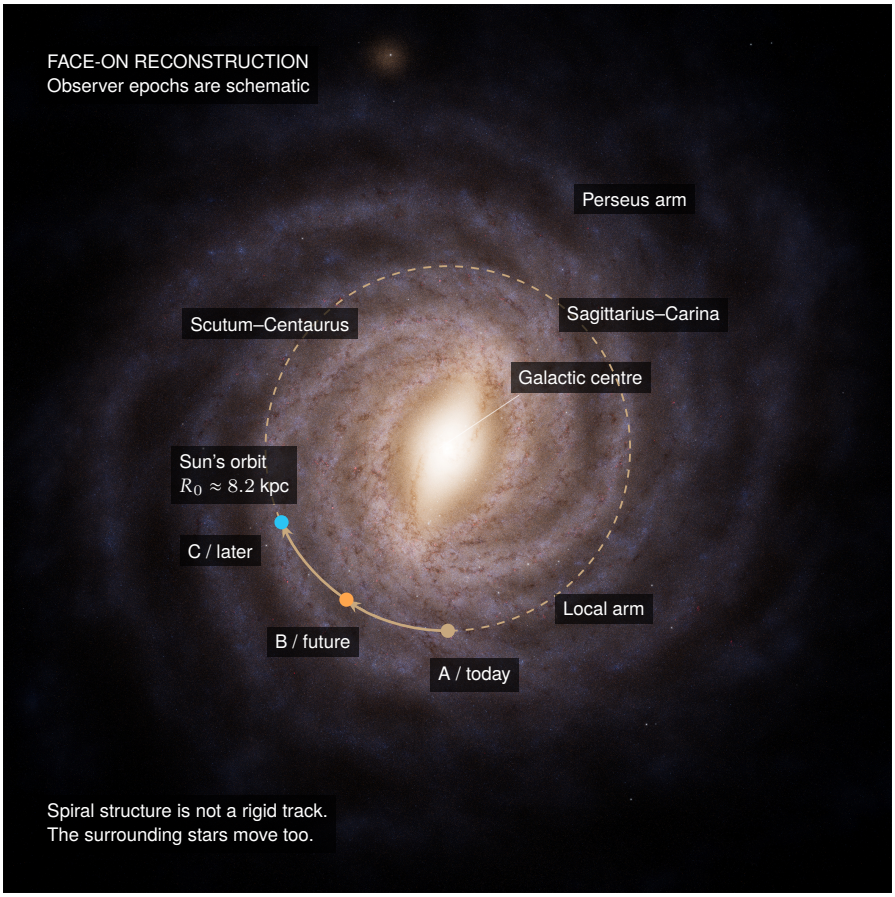


Figure 1: A new annotated rendering of the original question. ESA/Gaia/DPAC, Stefan Payne-Wardenaar reconstruction [1], adapted with vector labels. Epoch positions, orbit and arm-name placement are schematic, not fitted boundaries or a predicted future sky.

Working answer Relative motion can help or hinder a particular observation. In the selected century experiment, the imaging-accessibility sum changes by only **+0.0307%**; the specified instrument-improvement scenario changes it much more. Neither result forecasts life or a number of discoveries.

Project, full methods, original discussion note and reproducible code: biswajit1999.github.io/moving-observer/. This is a discussion report inviting expert criticism, not a claim of a new physical law.

02 / FROM A MAP TO A MEASURABLE QUESTION

Finding Earth 2.0 and changing sightlines

The related Finding Earth 2.0 observatory explores known exoplanets. Its saved 28 August 2026 analysis contains **6,354 confirmed planets and 4,764 host systems**, plus five Solar-System controls. This frozen snapshot is separate from the 1,387-source motion experiment on the next page.

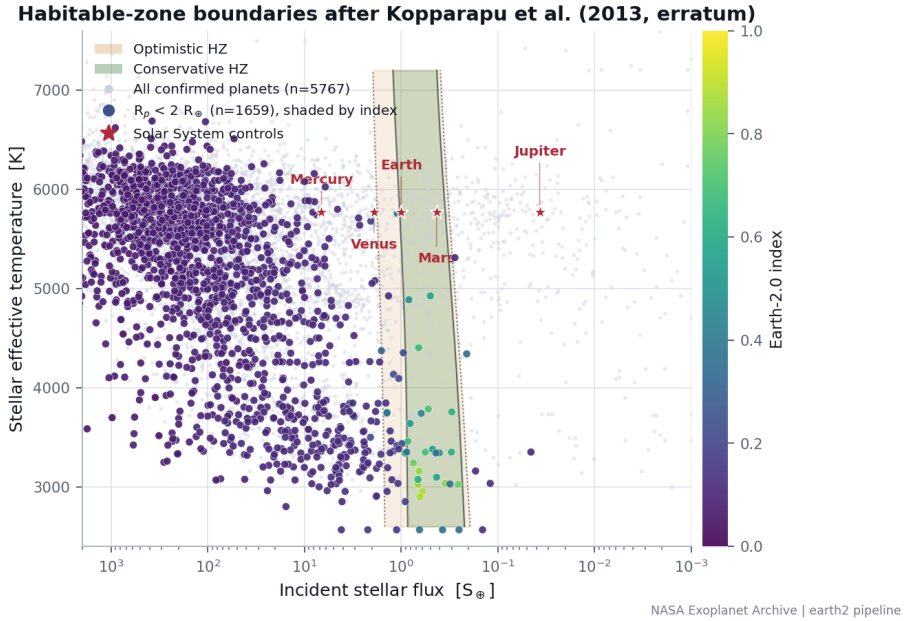


Figure 2: The original saved Finding Earth 2.0 plot [2]: 5,767 planets with incident-flux and temperature data; 1,659 have radii below two Earth radii. The similarity index is not a probability of life. Habitable-zone placement alone does not establish surface habitability.

Observer and target must share a reference frame

Let $\mathbf{r}_i$ be a target's position and $\mathbf{r}_{\rm obs}$ the observer's position. Their relative position $\mathbf{q}_i$, distance D_i and sightline $\widehat{\mathbf{n}}_i$ are

$$\mathbf{r}_{\rm obs}(t) = \mathbf{r}_\odot(t) + \mathbf{r}_{\oplus/\odot}(t), \qquad \mathbf{q}_i(t) = \mathbf{r}_i(t) - \mathbf{r}_{\rm obs}(t), \tag{1}$$

$$D_i(t) = \|\mathbf{q}_i(t)\|, \qquad \widehat{\mathbf{n}}_i(t) = \frac{\mathbf{q}_i(t)}{D_i(t)}. \tag{2}$$

For a sufficiently short interval,

$$\Delta\theta_i \simeq \frac{\|\mathbf{v}_{i,\mathrm{rel},\perp}\|\,\Delta t}{D_i}. \tag{3}$$

A transverse *relative* speed of $30\,\mathrm{km\,s^{-1}}$ at $100\,\mathrm{ly}$ gives about 20.6 arcseconds in 100 years. The Sun's total Galactic speed cannot be substituted for this relative transverse velocity.

A changed sightline is not automatically a new detection

For a circular orbit, transit geometry depends on the orbital inclination i to the sightline:

$$b(t) = \frac{a\cos i(t)}{R_\star}, \qquad |b| < 1 + \frac{R_p}{R_\star}, \qquad P_{\rm transit} \simeq \frac{R_\star + R_p}{a}. \tag{4}$$

Here b is the impact parameter, a the orbital radius, and $R_\star, R_p$ the stellar and planetary radii. An Earth–Sun analogue has an isotropic transit probability near 0.47%. Changing the view can open *or close* a transit window; detection also requires adequate signal, cadence and orbital phase. Time-dependent Earth-transit-zone membership is already established research [3].

03 / THE REPRODUCIBLE EXPERIMENT

How much does a century of motion change access?

We ask a narrower question than "how many planets will be found?": for the *same* nearby-source sample and hypothetical planet population, how does relative motion change single-visit direct-imaging accessibility? Four paired scenarios separate geometry from an assumed improvement in instrument thresholds.

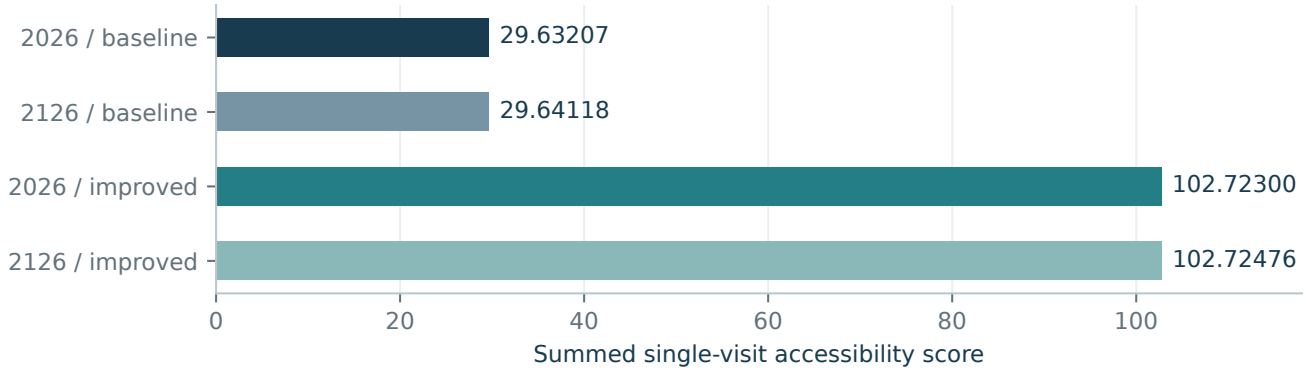


Figure 3: The baseline geometry change is visually tiny beside the chosen instrument change. Bar lengths are sums of conditional accessibility fractions, not planet counts. All four scenarios use the same 1,387 selected Gaia DR3 sources.

Data and assumptions

Gaia DR3 selection [4]: parallax $\geq$ 50 mas, parallax signal-to-noise $>$ 20, measured radial velocity, RUWE $<$ 1.4 and at least ten visibility periods. This is not a complete nearby-star census.

Each source receives a hypothetical Earth-radius planet on a circular 1 AU orbit with geometric albedo 0.3. The score averages over isotropic orientations and phases.

Threshold	Baseline	Improved
Inner working angle	60 mas	40 mas
Contrast floor	10^{-10}	5×10^{-11}
Planet magnitude limit	$G = 30$	$G = 31$

Result and uncertainty

The baseline sum changes from **29.63207 to 29.64118**. The motion contribution is

$$\Delta S_{\mathrm{motion}} = +0.009111 \quad (+0.03075\%).$$

The assumed instrument change adds **73.09093** at the initial epoch. These settings are sensitivity scenarios, not specifications for an approved telescope.

With 1,024 correlated astrometric draws per source, the formal 95% interval for the motion difference is **+0.00868 to +0.01152**. It excludes population and instrument uncertainty, binary-system errors and cross-source systematics.

What the score actually measures

For isotropic planet positions, $\cos\alpha$ is uniform. If the simultaneous angular-separation, contrast and magnitude conditions admit $[\alpha_{\min}, \alpha_{\max}]$, then

$$C_i = \frac{\cos\alpha_{\min} - \cos\alpha_{\max}}{2}, \qquad S = \sum_{i=1}^{1387} C_i, \tag{5}$$

with $C_i = 0$ for an empty interval. Averaging over orientation removes sensitivity to the absolute sky direction. Thus this experiment tests distance, brightness and separation thresholds; it does *not* follow known orbital planes into new transit bands.

A counterexample to "waiting helps" At the baseline settings, 42 sources gain and 45 lose accessibility. Changing only the inner working angle to 70 mas gives a net motion contribution near -0.00145. These are changes in scores, not discoveries. The next step is a targeted study with measured planetary orbital geometry.

04 / DISTANCE, DENSITY AND TIMESCALE

Are we entering a different neighbourhood?

Many disk stars share Galactic rotation but have different three-dimensional velocities. Their *relative* motions determine encounters. Radius from the Galactic centre and height above the plane describe different aspects of the environment; neither alone determines an individual star's speed.

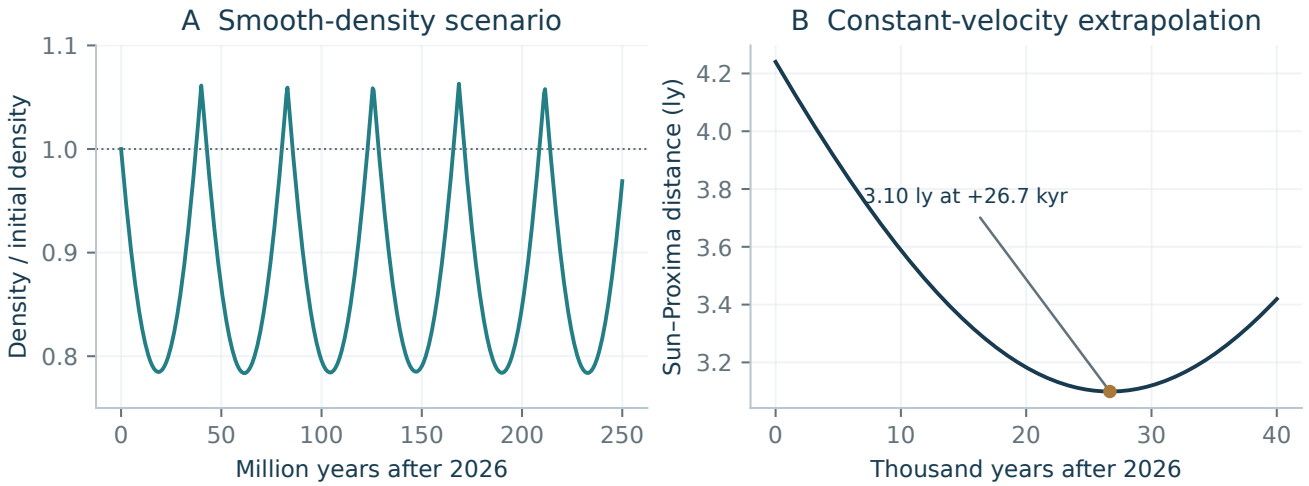


Figure 4: Two independent models with different clocks. A: adopted smooth-density profile along the Solar orbit. B: constant-velocity Sun–Proxima extrapolation. The apparent minimum in B is not a precision encounter forecast.

Density is not a discovery count

A historical census of 373 stars within 10 pc [5] sets the local reference:

$$n_0 = \frac{373}{(4\pi/3)(10\,\mathrm{pc})^3} = 0.0890\,\mathrm{pc}^{-3}.$$

The adopted thin/thick-disk scenario [6] ranges over **0.784–1.063** times its initial density in 250 Myr: about **292–397 stars** in an instantaneous 10 pc sphere. It omits spiral-arm enhancements, clusters and migration. These are neither distinct arrivals nor planets found.

Proxima is approaching now

The adopted historical inputs [7] give about **4.24 ly** in 2026 and a radial velocity of $-22.19\,\mathrm{km\,s^{-1}}$; distance is decreasing. The total relative speed is about $32.51\,\mathrm{km\,s^{-1}}$.

Straight-line propagation gives a minimum near **3.10 ly after 26,700 years**. This omits the Alpha Centauri system's orbital dynamics and Galactic differential acceleration. A negative radial speed today does not imply permanent approach.

The next 100, 1,000 and 10,000 years

Years	Solar path at 233 km/s	Median sightline shift	Accessibility change
100	0.0777 ly	44.4 arcsec	+0.0307%
1,000	0.7772 ly	443.9 arcsec	+0.2825%
10,000	7.7720 ly	1.2394°	+1.7069%

The last two columns use the same selected 1,387 Gaia sources and baseline imaging thresholds as page 3. They are nominal constant-relative-velocity calculations, with **no new uncertainty propagation** for the longer intervals. Binary dynamics and differential Galactic acceleration are omitted. The score responds to distance and thresholds, not sky angle alone.

Still local In 10,000 years, the model Sun sweeps only 0.01665° around the Galactic centre. A path of 7.77 light-years does not place it in a different spiral arm. Closer targets may be easier to study, but none of these results establishes life or predicts a habitable-planet discovery.

05 / PHYSICS BEHIND THE PICTURES

Reading the 3D simulation correctly

A trajectory's appearance depends on the reference frame. The same planet follows a closed orbit in a co-moving view and a winding path when Solar travel is included. This does not imply a universal helix through spacetime.

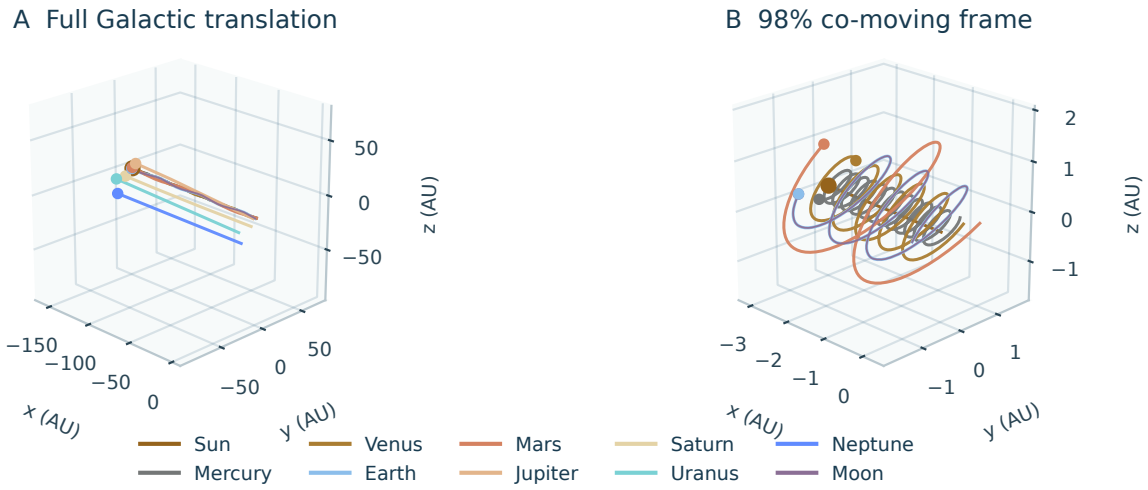


Figure 5: Three model years: A shows all ten bodies; B shows the Sun, inner planets and Moon. Each panel has equal AU axes with different displayed ranges. Markers are enlarged. Vector model plots, not website screenshots.

Three motions that should not be confused

Planetary reflex: the Sun moves around the Solar System barycentre in response to the planets. **Vertical Solar oscillation:** the long-clock orbit moves above and below the model Galactic midplane. **Galactic warp:** the displayed outer-disk bend is a separate kinematic illustration [8]. It does not supply an additional force to the Solar integration.

The long clock uses a nearly circular orbit in a static smooth potential. **A self-consistent evolution of the Galactic plane is not modelled.** The ecliptic's roughly $60°$ tilt is relative to the Galactic plane; it is not the inclination of the Sun's entire Galactic orbit.

A released probe keeps moving

A passive probe inherits its release velocity and accelerates under gravity. Leaving it outside Earth does not leave it at a fixed Galactic coordinate.

The cyan 2026 marker is a *hypothetical held reference*. Cancelling its velocity and holding it fixed would require a specified propulsion and force-compensation scheme. The simulation does not design such a mission.

The heliosphere is not a wall

The model marks a 120 AU heliopause, a 90 AU termination shock and radial 400 km/s wind tracers inside the shock. Real boundaries are asymmetric and time dependent [9]; energetic cosmic rays can penetrate. No MHD or radiation-transport calculation is claimed.

Gravity and clocks

For an isolated, nonrotating spherical body, a held clock and an ideal circular-orbit clock satisfy

$$\left(\frac{d\tau}{dt}\right)_{\text{held}} = \sqrt{1 - \frac{2GM}{rc^2}}, \tag{6}$$

$$\left(\frac{d\tau}{dt}\right)_{\text{circular}} = \sqrt{1 - \frac{3GM}{rc^2}}. \tag{7}$$

Here t refers to a clock at infinity. Relative to a stationary spherical-Earth surface clock, a circular clock loses **24.74 μs/day at 400 km** and gains **38.51 μs/day at 20,200 km** [10]. Rotation and operational corrections are excluded.

The whole-system view sums ten masses at a fixed test point using a weak-field clock rate. The potential sheet has arbitrary display depth.

A tested approximation, not full GR The separate coupled 1PN lab starts from JPL states [11]. Its two-body Mercury benchmark gives 42.9798 arcsec/century against 42.9807 analytically. The ten-year lunar discrepancy reaches 215 km. This is not a navigation ephemeris.

06 / EXPLORE, REPRODUCE AND CRITIQUE

A guide for readers and prospective mentors

Five ways to explore

1. **Inspect Galactic evidence.** Separate the 199 VLBI entries [12] from the ESA/Gaia reconstruction. *Show warped disk* selects labelled 5× height; restore 1× for true proportions.
2. **Resolve 100 light-years.** Open the journey preview: this takes about 128,608 model years. The recording control captures the local scene while the tab remains visible.
3. **Change the frame.** In *Sun & all planets*, compare full Galactic and 98% co-moving paths. *Inspect a planet* follows a selected body at physical radius; *Whole system* restores context.
4. **Read physical quantities.** *Space & Time* shows the whole system on a years clock; selecting Earth opens a local clock experiment. The 1PN lab integrates coupled dynamics separately.
5. **Test gas separately.** The gas lab solves 2D isothermal Euler flow on a 64×64 grid. Height graphs density, not warp. It is not a fitted 3D/MHD Galaxy simulation.

Questions for the community

A feasible next test. Which known systems have planetary orbital planes and relative velocities well enough constrained to test entry into a transit band?

A realistic observing programme. Which apparent gains survive exposure-time budgets, repeated visits, binaries and instrument noise?

A second observer. What physically feasible probe orbit would add a useful baseline beyond Earth's orbit and long-term astrometry?

Relevant prior work. Which studies best connect changing sightlines, nearby encounters and exoplanet detection opportunities?

I am an independent researcher without a formal supervisor. I built this software out of curiosity and would welcome expert guidance on what is useful, what is already established, and what needs correction.

Selected sources and provenance

[1] ESA/Gaia/DPAC; S. Payne-Wardenaar (2025). Milky Way reconstruction. CC BY-SA 3.0 IGO; annotated here.
[2] Finding Earth 2.0. Saved analysis, 28 Aug 2026. Original habitable-zone plot; repository and methods.
[3] Kaltenegger & Faherty (2021). Past, present and future stars that can see Earth as a transiting exoplanet.
[4] Gaia DR3 (2022). Catalogue release; sample selection and covariance treatment in the full methods.
[5] Reylé et al. (2021). The 10 parsec sample in the Gaia era. Historical local-census normalization.
[6] Jurić et al. (2008). Milky Way tomography with SDSS. Basis of the adopted smooth-density scenario.
[7] Kervella, Thévenin & Lovis (2017). Proxima / Alpha Centauri measurement inputs.
[8] Poggio et al. (2025). The great wave: outer-disk warp and corrugation. Not fitted by this simulation.
[9] NASA. Uncovering our Solar System's shape. Heliosphere structure and observational context.
[10] Ashby (2003). Relativity in the Global Positioning System.
[11] Park et al. (2021). JPL DE440/DE441 planetary and lunar ephemerides.
[12] Reid et al. (2019). Trigonometric parallaxes and Galactic spiral structure. VLBI data and arm fits.

Figure 2 is the original saved plot; figures 3–5 are vector plots of project calculations. The original discussion note is preserved unchanged. Planet maps in the simulation: Solar System Scope / INOVE, CC BY 4.0, with illustrative surface and orientation choices. No institutional endorsement is implied.

Open the project Simulation and full methods | Source, data and LaTeX | Questions and scientific criticism