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От Сильченко О.К.

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Chronology of our Galaxy from *Gaia* colour–magnitude diagram fitting (ChronoGal)

IV. On the inner Milky Way stellar age distribution

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Пять эпох SF для сверхметалличных звезд – рожденных в балдже?

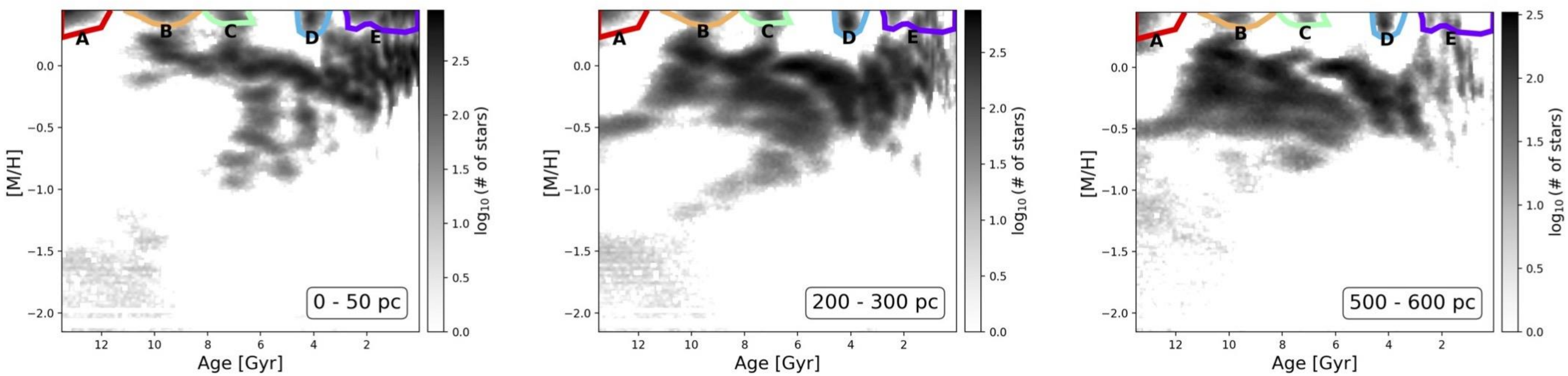

Fig. 1. Stellar density distribution in the age-metallicity plane for volumes 1, 5, and 8 (i.e. from the plane to 50 pc, 0.2 to 0.3 kpc, and 0.5 to 0.6 kpc, respectively above and below the plane) as representative examples of the reported super metal-rich populations (for these we use the Lallement et al. 2022 dust map). Coloured polygons delimit the areas in the age-metallicity plane used to quantify the *z*-profiles in Fig. 2. Note that a logarithmic scale has been used to represent the number of stars, in order to enhance these relatively low intensity features.

Толщина этих звездных подсистем

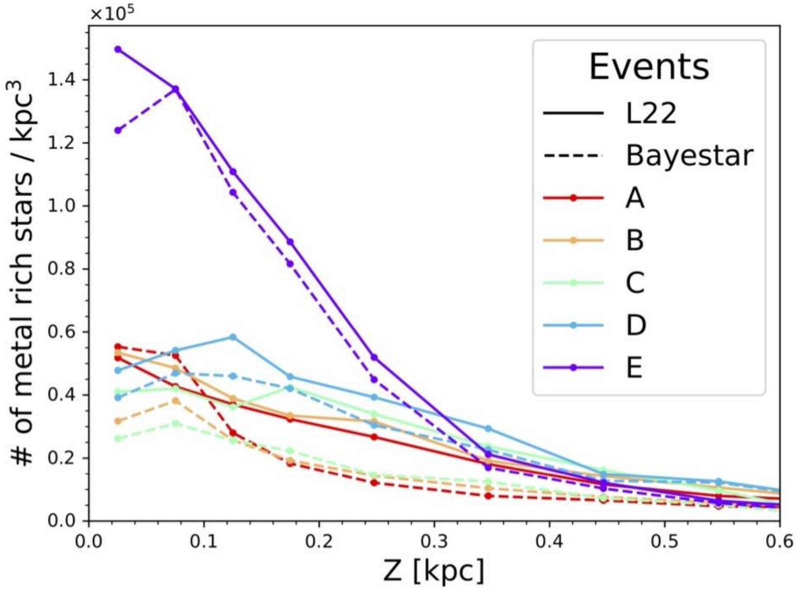

Fig. 2. *z*-profile of number density of stars for the five different events of super metal-rich star formation. Such events are defined using the polygons depicted in Fig. 1. We show the profiles using two different extinction maps, Bayestar map (Green et al. 2019, dashed lines), and Lallement et al. (2022) map (solid lines, L22). Given incompleteness affecting the observed samples together with quality cuts, absolute values for this number density should be taken with caution. A normalisation has been applied to the Bayestar densities to account for the missing quadrant in the Bayestar coverage (see Green et al. 2019). Colours follow Fig. 1.

AURIGA симуляции для аналога окрестностей Солнца

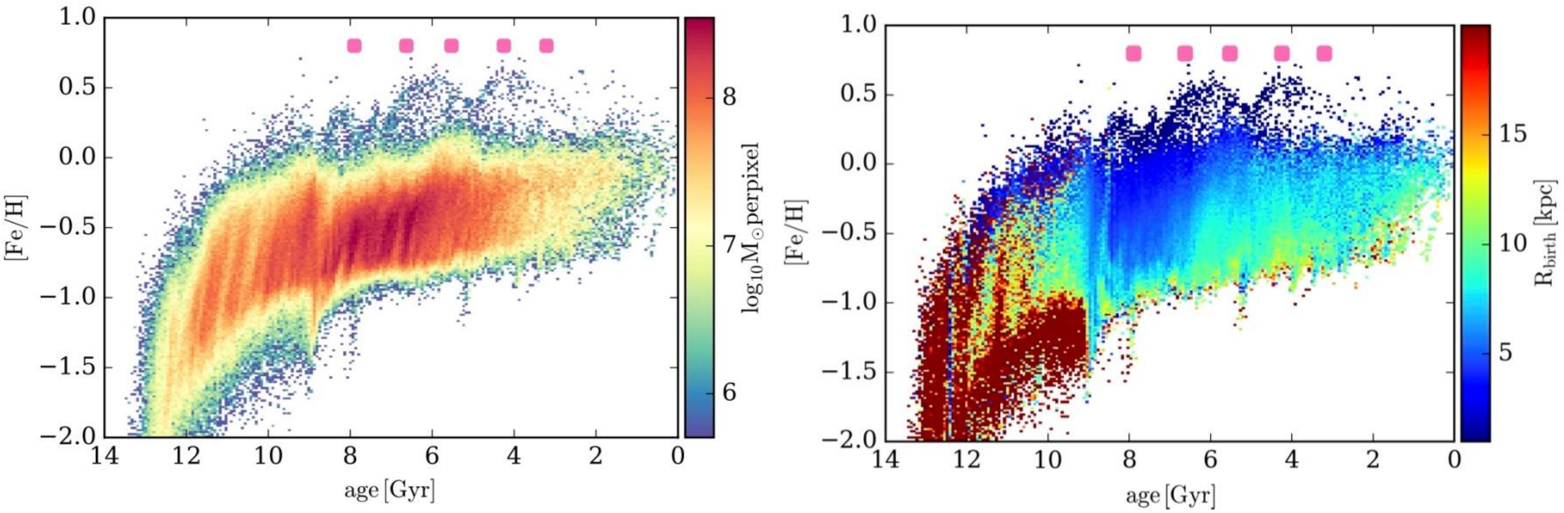

Fig. 3. Stellar age-metallicity distribution of stellar particles for a solar neighbourhood-like selection of stars from AuS18. The distribution of stars are colour-coded according to number density (left) and birth radius (right). Pericentric passages of subhalo 6281 are shown as pink squares.

Изохроны для этих выделенных эпох – ДРУГИЕ ДАННЫЕ

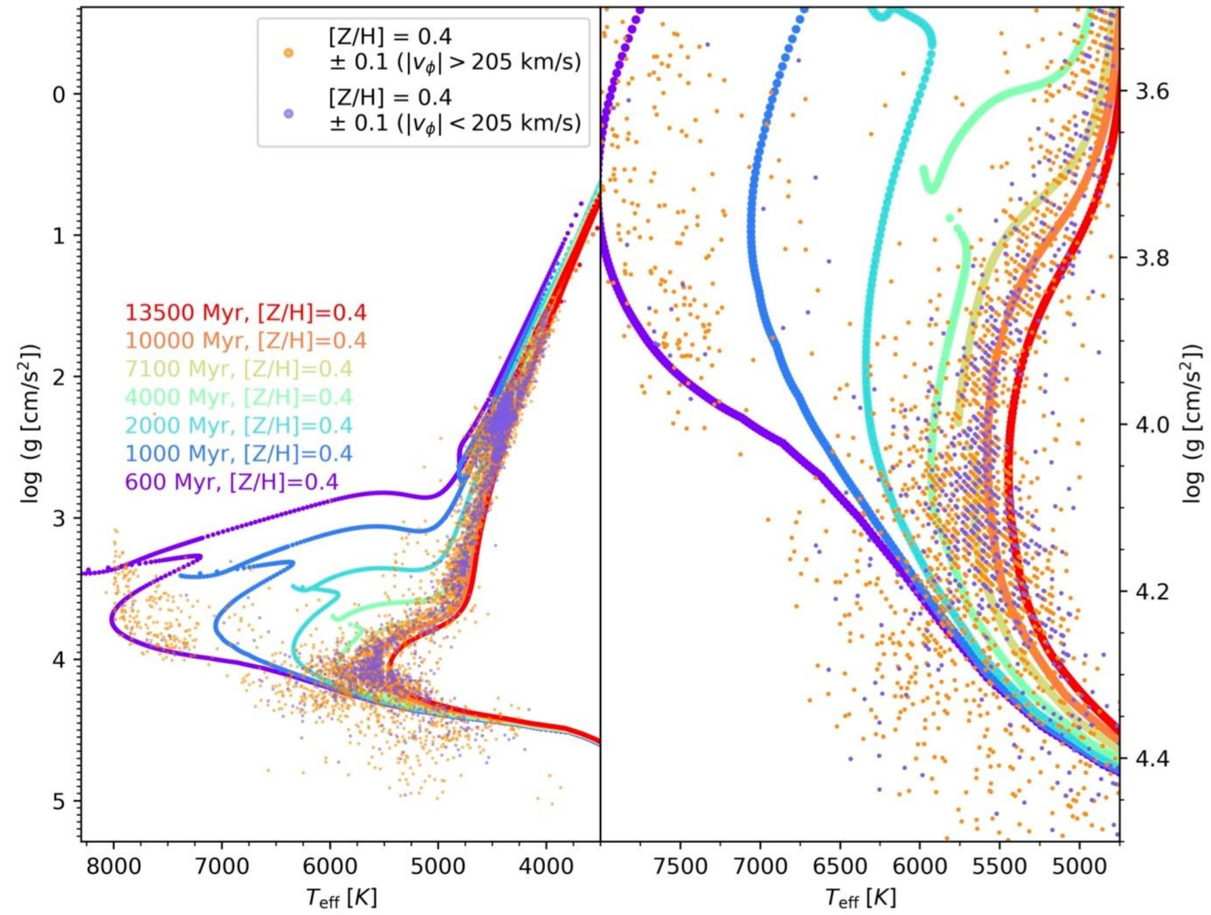

Fig. 4. Kiel diagram of the disc super metal-rich population with [M/H]=0.4±0.1 dex. We divide the sample in two based on their value of v_ϕ: slow (purple) and fast (orange) stars (see Fig. 5). Solar-scaled BaSTI isochrones of 13.5, 10, 7, 4, 2, 1, and 0.6 Gyr (red, orange, pistacho, green, cyan, blue, and purple, respectively) are overlaid on the data. *Left:* Whole diagram. *Right:* Focusing only on the turn-off region.

Кинематика подсистем – разные механизмы миграции?

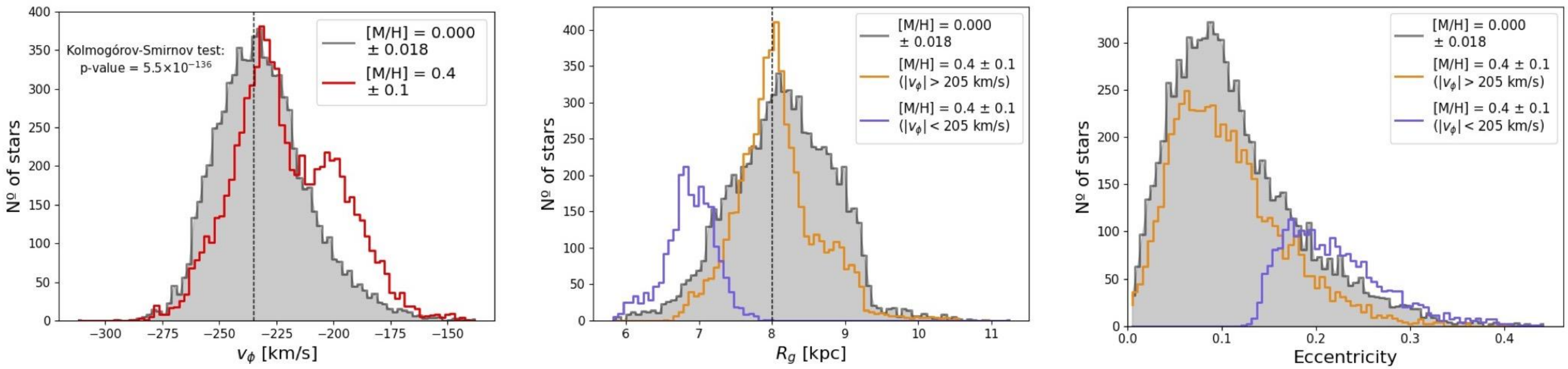

Fig. 5. Orbital properties of the metal-rich stars detected in the high-quality Gaia DR3 GSP-Spec sub-catalogue from Recio-Blanco et al. (2024), compared with those of a subset of solar-metallicity stars. *Left:* Distribution of v_ϕ velocities for metal-rich (red, empty histogram) and solar-metallicity (grey histogram) stars. From the shape of the metal-rich stars histogram we divide the sample in slow ($|v_\phi|$ below 205 km/s) and fast ($|v_\phi|$ above 205 km/s) stars. *Middle:* Distribution of guiding radius (from Recio-Blanco et al. 2024). *Right:* Distribution of eccentricity (from Recio-Blanco et al. 2024). For these last panels, we divide the sample in solar metallicity (grey), slow, metal-rich stars (purple) and fast, metal-rich stars (orange).

История звездообразования в окрестностях Солнца

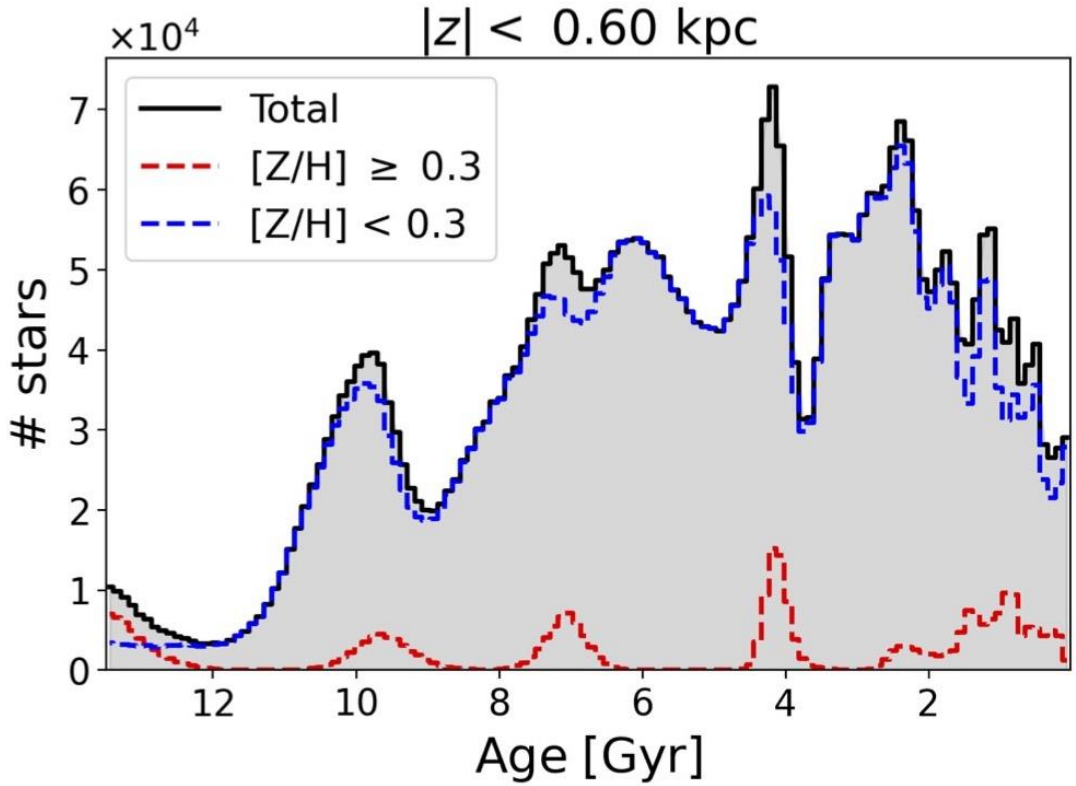

Fig. 6. Integrated stellar age distribution of the stars within 0.6 kpc of the plane of the disc (|z|<0.6 kpc). We divide it into total (including all stars, shaded black area); metal-rich (considering only stars with [M/H] ≥ 0.3, red); and rest (stars with [M/H] < 0.3, blue).

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No Observational Evidence for Dark Matter Nor a Large Metallicity Spread
in the Extreme Milky Way Satellite Ursa Major III / UNIONS 1

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ABSTRACT

The extremely-low-luminosity, compact Milky Way satellite Ursa Major III / UNIONS 1 (UMaIII/U1; $L_V = 11\ L_\odot$; $a_{1/2} = 3$ pc) was found to have a substantial velocity dispersion at the time of its discovery ($\sigma_v = 3.7^{+1.4}_{-1.0}$ km s^{-1}), suggesting that it might be an exceptional, highly dark-matter-dominated dwarf galaxy with very few stars. However, significant questions remained about the system's dark matter content and nature as a dwarf galaxy due to the small member sample ($N = 11$), possible spectroscopic binaries, and the lack of any metallicity information. Here, we present new spectroscopic observations covering $N = 16$ members that both dynamically and chemically test UMaIII/U1's true nature. From higher-precision Keck/DEIMOS spectra, we find a 95% confidence level velocity dispersion limit of $\sigma_v < 2.3$ km s^{-1}, with a $\sim$120:1 likelihood ratio favoring the expected stellar-only dispersion of $\sigma_* \approx 0.1$ km s^{-1} over the original 3.7 km s^{-1} dispersion. There is now no observational evidence for dark matter in the system. From Keck/LRIS spectra targeting the Calcium II K line, we also measure the first metallicities for 12 member stars, finding a mean metallicity of [Fe/H] $= -2.65 \pm 0.1$ (stat.) $\pm\ 0.3$ (zeropoint) with a metallicity dispersion limit of $\sigma_{\rm [Fe/H]} < 0.35$ dex (at the 95% credible level). Together, these properties are more consistent with UMaIII/U1 being a star cluster, though the dwarf galaxy scenario is not fully ruled out. Under this interpretation, UMaIII/U1 ranks among the most metal-poor star clusters yet discovered and is potentially the first known example of a cluster stabilized by a substantial population of unseen stellar remnants.

Карлик Ursa Major III/ UNIONS1

- В 10 кпк от Солнца
- Полная светимость – 11 солнечных
- Дисперсия скоростей звезд 3.7 км/с
- Радиус 3 пк
- Отсюда динамическая масса, и M/L_V=6500

Проверили членство, добавили звезд и спектров

C. CA II K SPECTRA FOR ALL LRIS PROGRAM TARGETS

In Figure 6, we present the complete set of LRIS spectra used for our metallicity analysis.

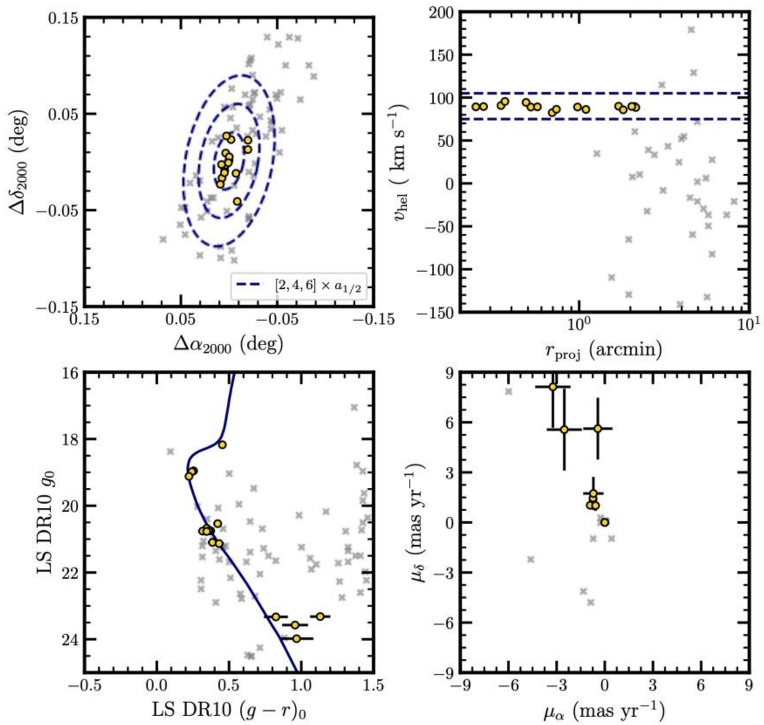
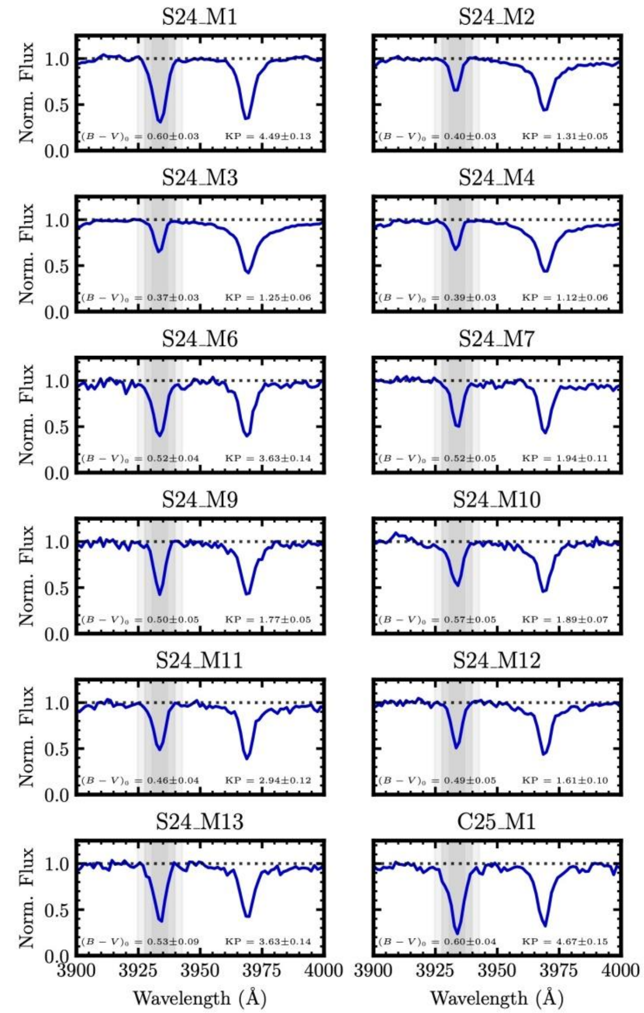


Figure 5. Four diagnostic views of our complete, dual-epoch DEIMOS spectroscopic sample. In each panel, UMaIII/U1 members are shown in gold while non-members are shown as grey crosses. (Top Left) Spatial positions of stars in a $0.3° \times 0.3°$ square region centered on UMaIII/U1. Contours depicting $2, 4, 6\times$ the system's semi-major axis ($a_{1/2}$) are shown in blue. (Top Right) Velocity vs. projected radius for the same samples of stars. (Bottom Left) Color–magnitude diagram based on Legacy Surveys DR10 photometry (Dey et al. 2019), with a $\tau = 12$ Gyr, [Fe/H] $= -2.19$ PARSEC isochrone overplotted in blue. We draw attention to the impressive depth of the DEIMOS observations – reaching $g_0 \sim 24$. (Bottom Right) *Gaia* DR3 proper motion vector-point diagram for the subset of brighter stars with measurements available. Although three stars have larger proper motion errors, there is a clear clustering among the remaining stars.



10 звезд перенаблюдали на DEIMOS + 5 новых звезд-членов

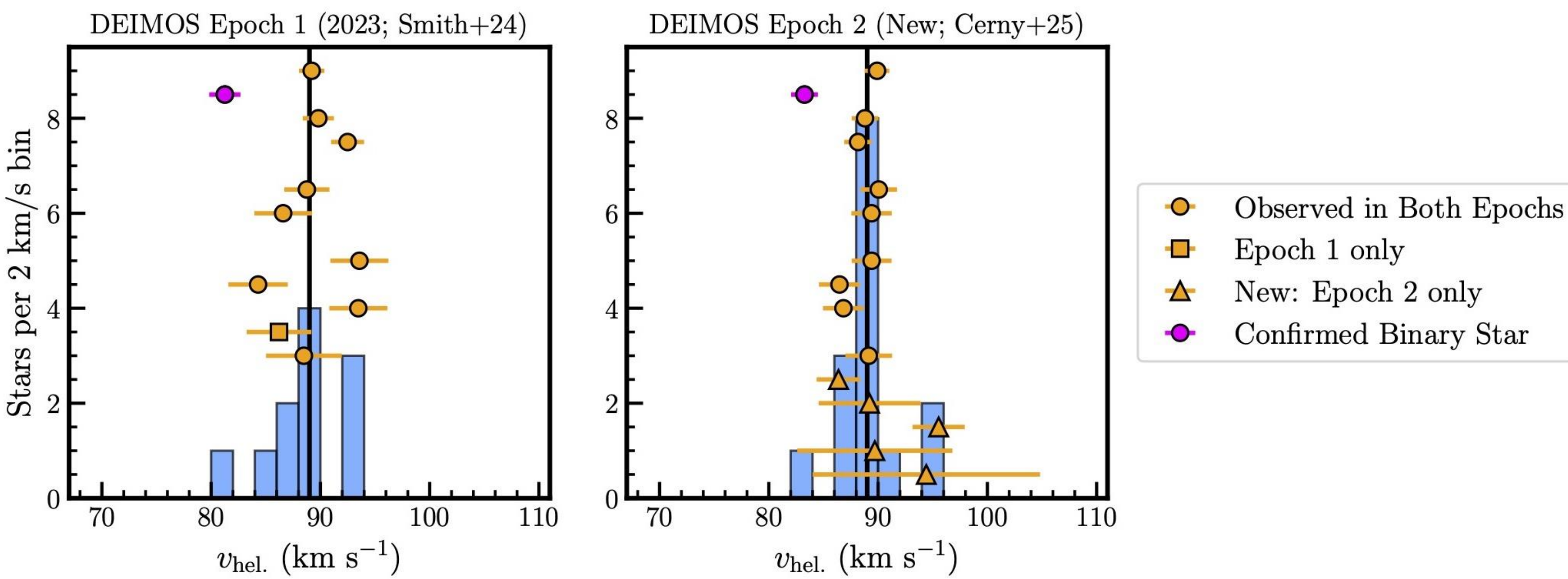


Figure 1. The velocity distribution of UMaIII/U1 members from the re-reduced 2023 epoch (left) and the deeper April 2025 epoch (right), all from Keck/DEIMOS. The original 2023 epoch identified 11 members; in 2025 we successfully re-observed 10 of these stars with DEIMOS and added five new members (including two with good precision and three with larger uncertainties). In the deeper second epoch, which yielded significantly more precise measurements, we observe a clear regression to the mean in most member stars. The binary star that we monitored (S24_M2; in magenta) remains a clear outlier in each panel, but we note that the evidence for binarity is based primarily on the GMOS/MagE/HIRES data not shown here.

Новое ограничение на дисперсию скоростей после исключения двойных

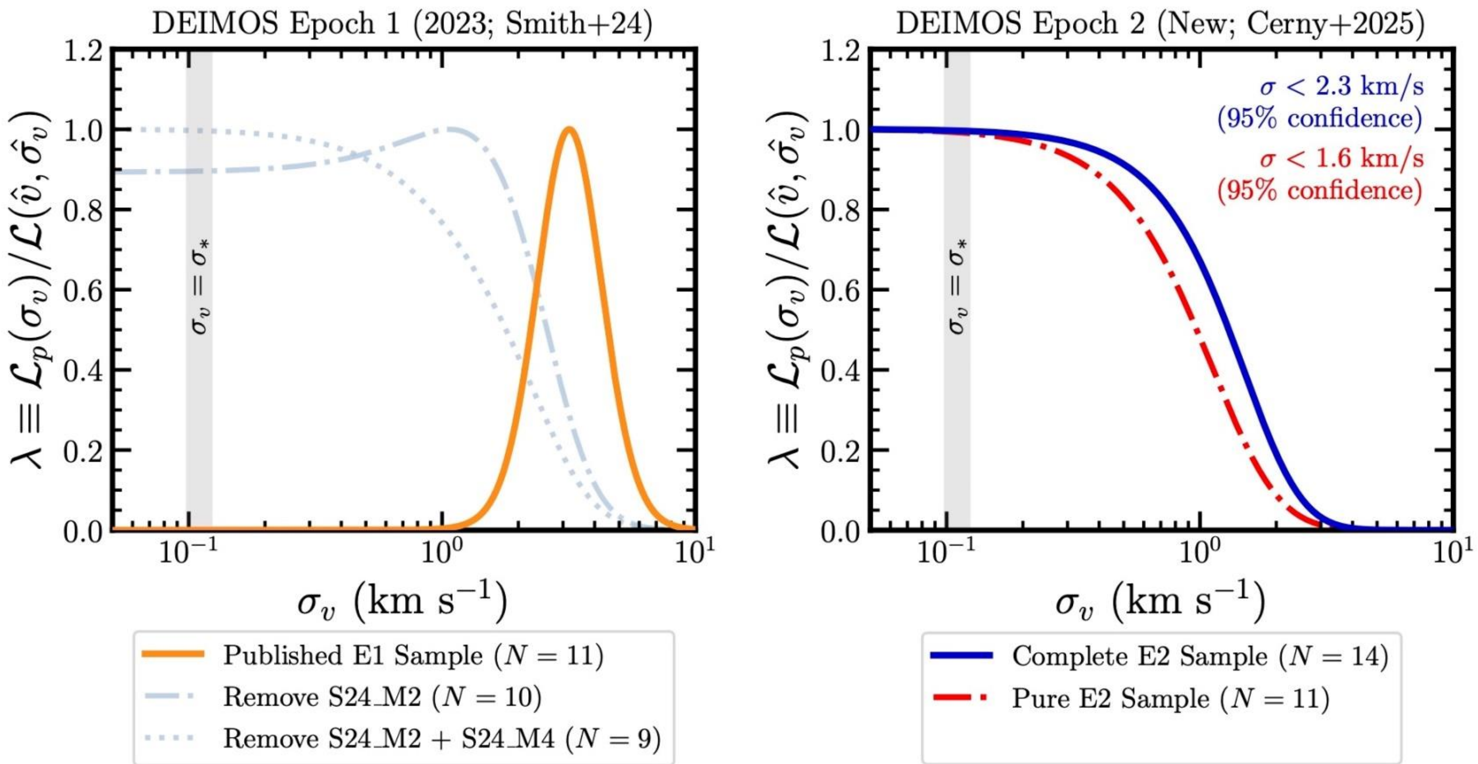


Figure 2. Stringent limits on the velocity dispersion of Ursa Major III/UNIONS 1. We display the normalized profile likelihoods for the velocity dispersion (σ_v) for the re-reduced 2023 DEIMOS observations (left) and the new 2025 DEIMOS observations (right), using different member subsets in each case. The left panel reproduces the conclusions of S24, demonstrating the clearly-resolved dispersion when all 11 original members were included (solid orange). In the righthand panel, we display our primary constraints from this work for the Complete Epoch 2 (blue) and Pure Epoch 2 (red) samples. The likelihood in both cases is maximized for the smallest allowed dispersions, and the original dispersion of $\sigma_v = 3.7$ km s^{-1} is clearly ruled out.

Про металличность: нет разброса

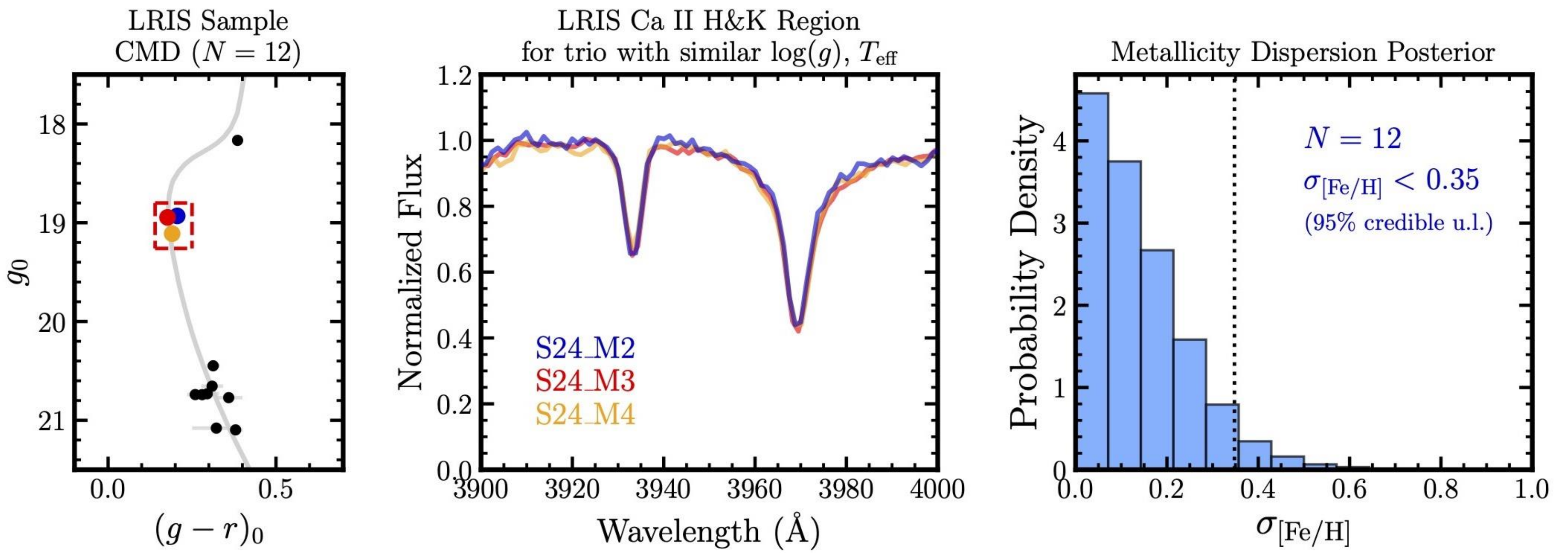


Figure 3. The absence of a significant metallicity spread in UMaIII/U1. (Left) Color–magnitude diagram of the 12 UMaIII/U1 stars observed with Keck/LRIS (using PanSTARRS-1 photometry). We box three stars with similar stellar parameters that are useful for tests of chemical homogeneity. (Center) The LRIS spectra for the three boxed stars (`S24_M2`,`S24_M3`, and `S24_M4`) covering the Calcium H and K lines. The three spectra are very similar, suggesting similar metallicities for these three stars given their similar surface gravities and temperatures ([Fe/H] $= -2.87 \pm 0.33$, -2.90 ± 0.34, -2.99 ± 0.34). See Figure 6 for the LRIS spectra of the remaining nine stars. (Right) Marginalized posterior probability distribution on the intrinsic metallicity dispersion of UMaIII/U1 ($\sigma_{\rm [Fe/H]}$) derived from the complete LRIS sample of 12 member stars.

Сравнение с другими карликами

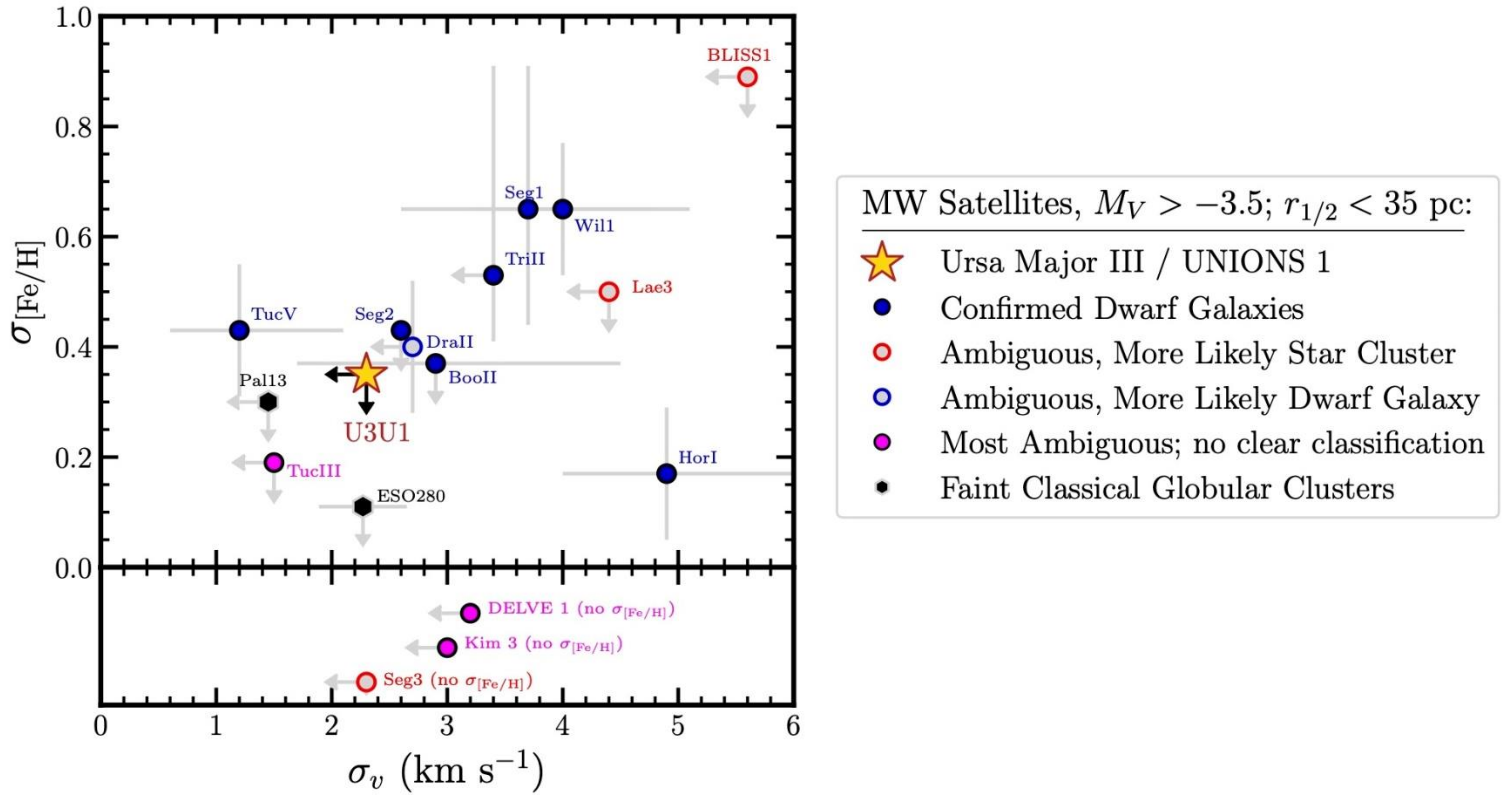


Figure 4. UMaIII/U1's low velocity dispersion limit and metallicity dispersion limit in the context of the faint, compact Milky Way satellite population. We compare our new measurements for the system to a carefully curated sample of systems with $M_V > -3.5$; $r_{1/2} < 25$ pc for which there are both $\sigma_{[Fe/H]}$ and σ_v measurements available (top sub-panel) or only a σ_v measurement (bottom sub-panel); we exclude systems with possibly contaminated/impure stellar memberships. These include confirmed dwarf galaxies (filled blue), ambiguous compact systems (unfilled red or blue, for systems more likely to be clusters or dwarfs, respectively; magenta if entirely unclear), and select globular clusters (black). Our new limits for UMaIII/U1 rank among the strongest of any ultra-faint system in this size and luminosity regime; the only system with stronger limits for both types of dispersion is Tucana III. See Appendix D for a discussion of the comparison sample (and associated references).

Вывод:

- Ursa Major III/UNIONS 1 – не карликовая галактика, у нее нет динамических признаков темной материи (σ <2.3 км/с при выкидывании одной двойной и < 1.4 км/с при выкидывании 4х двойных).
- Кроме того, нет разброса металличностей звезд, как у карликовых галактик.
- Похоже, это шаровое (?) скопление: [Fe/H]=-2.65, T=12 млрд лет, масса $<10^4$.