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Spatially Resolved Stellar Spectroscopy of the Ultra-diffuse Galaxy Dragonfly 44. III. Evidence for an Unexpected Star-Formation History

Alexa Villaume,[1,2,*] Aaron J. Romanowsky,[3,4] Jean Brodie,[5] Pieter van Dokkum,[6] Charlie Conroy,[7] Duncan Forbes,[5] Shany Danieli,[6,8,9,10,†] Christopher Martin,[11] and Matt Matuszewski[11]

[1] *Department of Astronomy & Astrophysics, University of California Santa Cruz, 1156 High Street, Santa Cruz, CA 95064, USA*

[2] *Waterloo Centre for Astrophysics, Department of Physics & Astronomy, University of Waterloo, 200 University Ave. W., Waterloo, Ontario, Canada N2L 3G1*

[3] *Department of Physics & Astronomy, San Jose State University, One Washington Square, San Jose, CA 95192, USA*

[4] *University of California Observatories, 1156 High Street, Santa Cruz, CA, 95064, CA, USA*

[5] *Centre for Astrophysics & Supercomputing, Swinburne University, Hawthorn VIC 3112, Australia*

[6] *Astronomy Department, Yale University, 52 Hillhouse Avenue, New Haven, CT 06511, USA*

[7] *Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, Cambridge, MA, USA*

[8] *Department of Physics, Yale University, New Haven, CT 06520, USA*

[9] *Yale Center for Astronomy and Astrophysics, Yale University, New Haven, CT 06511, USA*

[10] *Institute for Advanced Study, 1 Einstein Drive, Princeton, NJ 08540, USA*

[11] *Cahill Center for Astrophysics, California Institute of Technology, 1216 East California Boulevard, Mail Code 278-17, Pasadena, CA 91125, USA*

ABSTRACT

We use the Keck Cosmic Web Imager integral-field unit spectrograph to: 1) measure the global stellar population parameters for the ultra-diffuse galaxy (UDG) Dragonfly 44 (DF44) to much higher precision than previously possible for any UDG, and 2) for the first time measure spatially-resolved stellar population parameters of a UDG. We find that DF44 falls below the mass–metallicity relation

Наблюдения и анализ: Keck+Conroy

the integrated spectrum. With KCWI, 17 hours of on-target exposure time achieved a S/N $\sim$ 96 Å^{-1} for the integrated spectrum and 12–20 Å^{-1} for the spatially-resolved spectra.

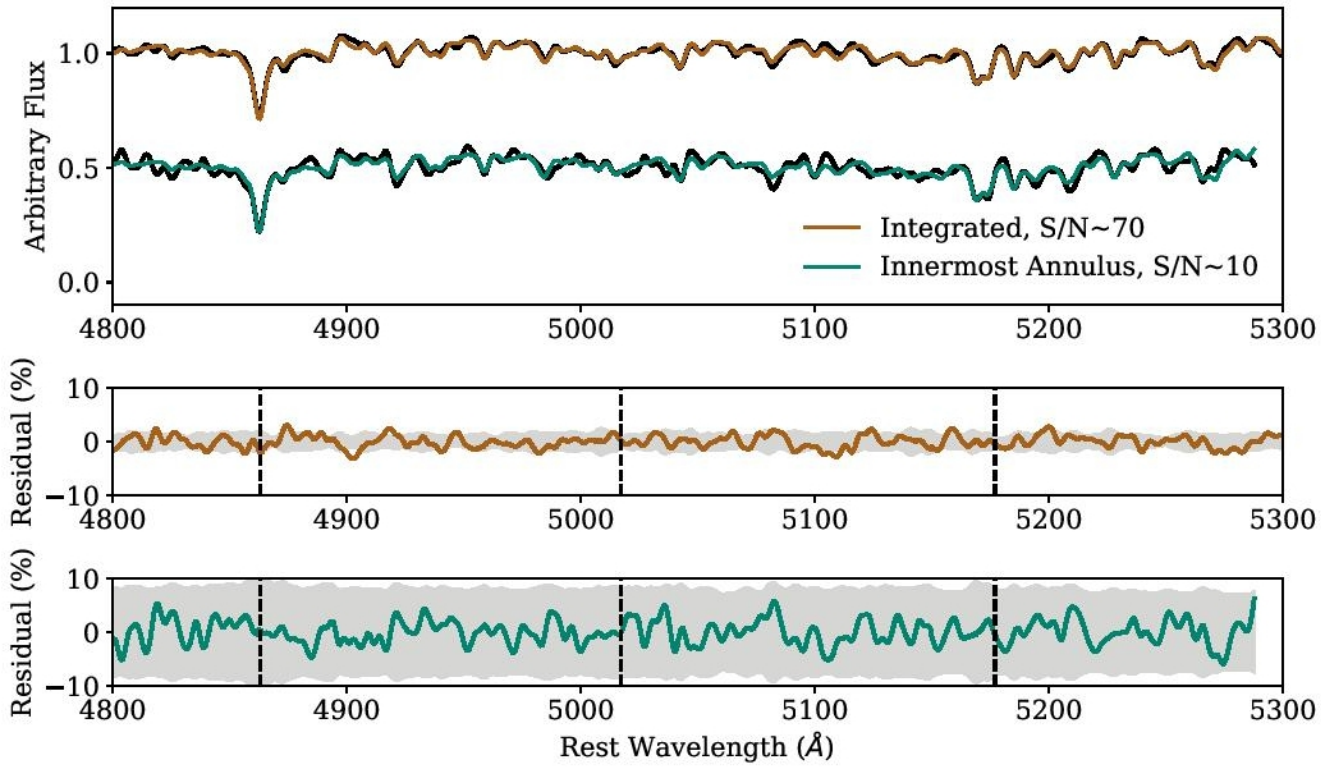
We used the Medium slicer on KCWI, yielding a spectral resolution of $R \sim 4000$. This necessitated smoothing the data to the native resolution of the `alf` models, 100 km s^{-1}. It has been previously demonstrated

We fit over the wavelength regions $4800 \leq \lambda$Å(obs) ≤ 5150 and $5150 \leq \lambda$Å(obs) ≤ 5300. Unless otherwise stated, the results presented in this paper are from using the "simple" mode in `alf` which fixes the stellar initial mass function (IMF) at Kroupa (2001) and fits for a single age. We use the standard priors (see Conroy et al. 2018, for details), except for the prior on [Mg/Fe]. Based on examination of the posteriors, we changed the lower prior to be [Mg/H]$= -1.0$ for the final fits presented in this work.

Fitting: интегральный спектр и 9й эллипс

Percentile	log Age (Gyr)	[Fe/H]	[Mg/Fe]
16	0.95	−1.31	0.07
50	0.99	−1.27	0.11
84	1.03	−1.23	0.17

Table 1. The 16th, 50th, and 84th percentiles of the global stellar population parameters measured from the integrated KCWI spectrum of DF44.



Аномально низкая металличность?

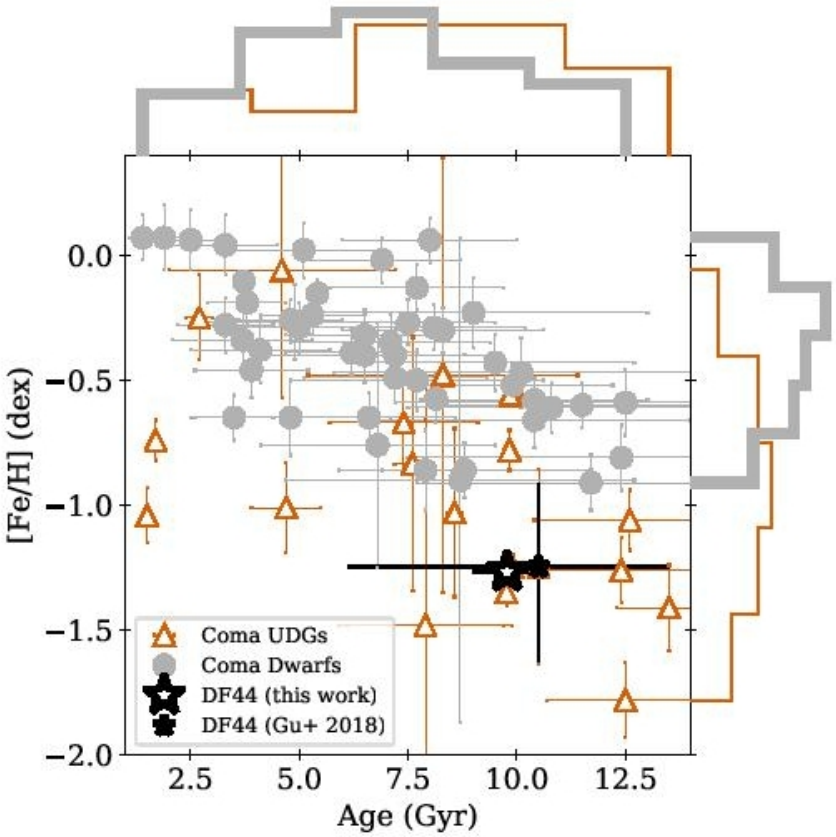
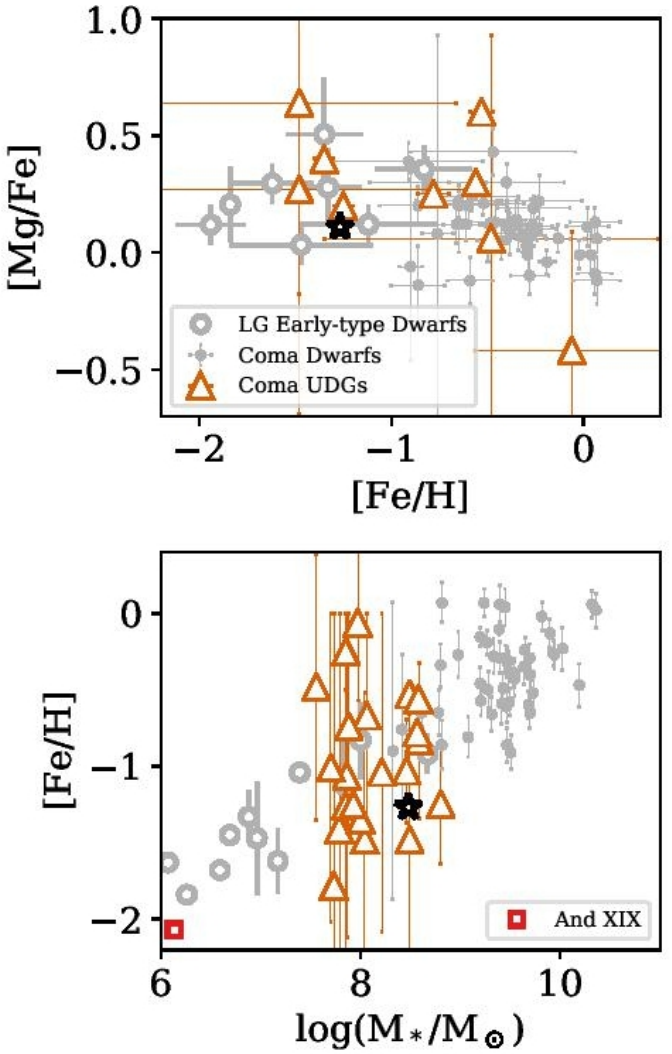


Figure 2. Comparing the relation between global age and [Fe/H] for a compilation of Coma UDGs (orange) and typical Coma dwarf galaxies (grey). The measurements for DF44



Ход параметров по радиусу

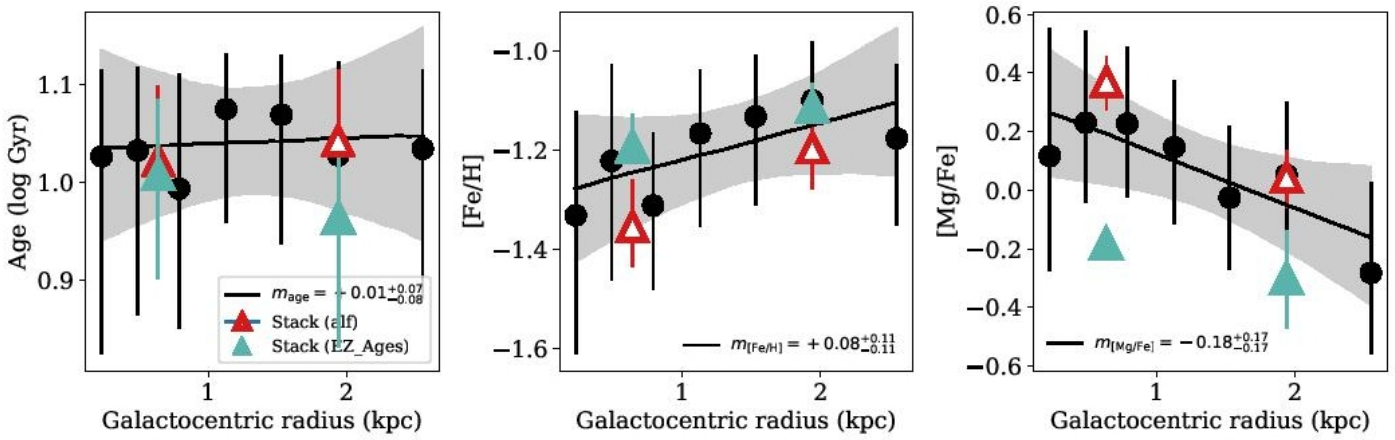


Figure 5. Radial profiles of DF44 stellar population parameters (black circles). Also shown are the measurements of two radial bins using both `alf` (open red triangles) and `EZ_AGES` (filled blue triangles). From left to right: log stellar age, [Fe/H], and [Mg/Fe]. These results suggest that DF44 formed "inside-out."

Aperture	R (kpc)	log Age (Gyr)	[Fe/H] (dex)	[Mg/Fe] (dex)
0	0.23	1.03	−1.33	0.12
1	0.49	1.03	−1.22	0.23
2	0.79	0.99	−1.31	0.23
3	1.13	1.08	−1.17	0.15
4	1.53	1.07	−1.13	−0.03
5	1.94	1.03	−1.10	0.05
6	2.55	1.03	−1.18	−0.28

Table 3. The 50th percentiles of the stellar population parameters measured from the spatially-resolved spectra.

Градиент цвета и сравнение с шаровыми скоплениями MW

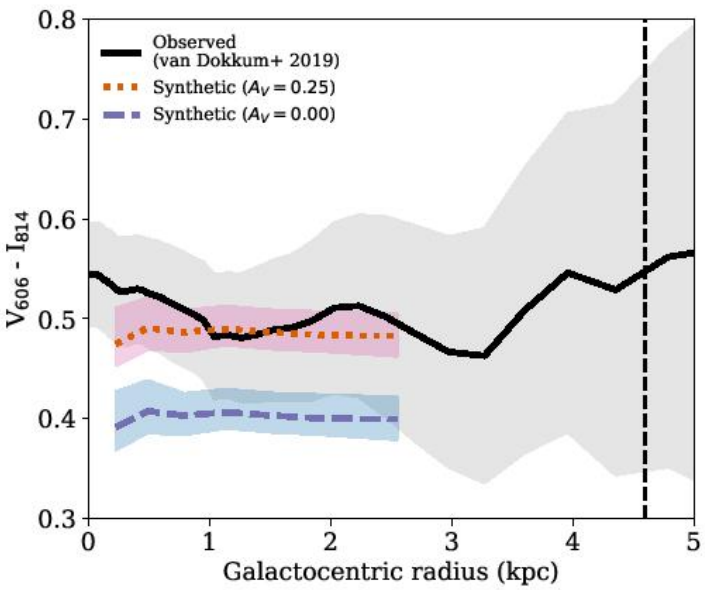


Figure 6. Comparison of observed DF44 color profile (gray) to synthetic color profiles generated from the best-fit models of the spatially-resolved spectra without dust extinction (blue) and with dust extinction (red). The overall shape of the synthetic color profile is consistent with the observed color profile but there is a small offset in overall color. Independent analysis of near-infrared photometry indicates there may be a dust component in DF44. The color profile does not change appreciably between the outer range of the spectroscopic coverage and the half-light radius (black vertical

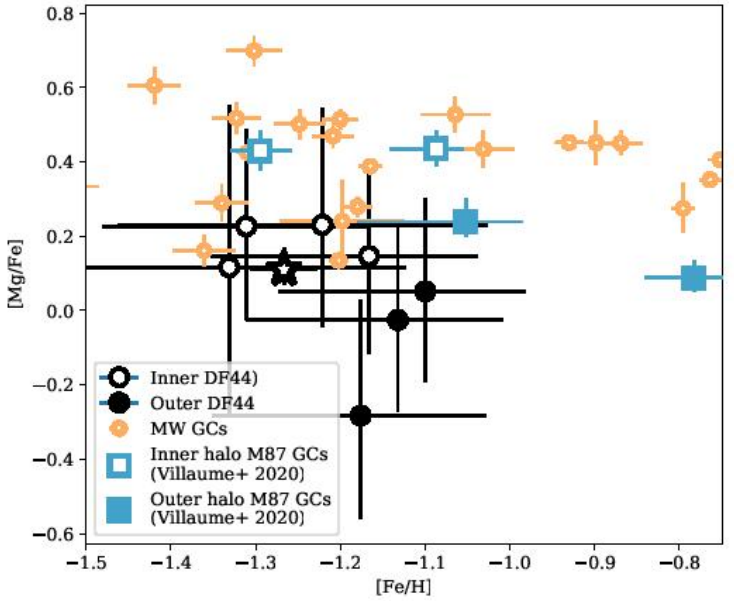


Figure 7. Comparing the spatially-resolved measurements of DF44 to spatially-resolved measurements from spectral stacks of M87's inner halo GC population ($R_{\rm gal} < 40$ kpc, open blue squares) and outer halo GC population ($40 < R_{\rm gal}$ kpc < 140), filled blue squares), and individual Milky Way GCs (open orange circles). The DF44 measurements are split between the inner sample ($R_{\rm gal} < 1.5$ kpc, open black circles) and the outer sample (filled black circles). The similarity between DF44's central region and the metal-poor subpopulation suggest a potentially coeval evolution.

Где же родственники?!

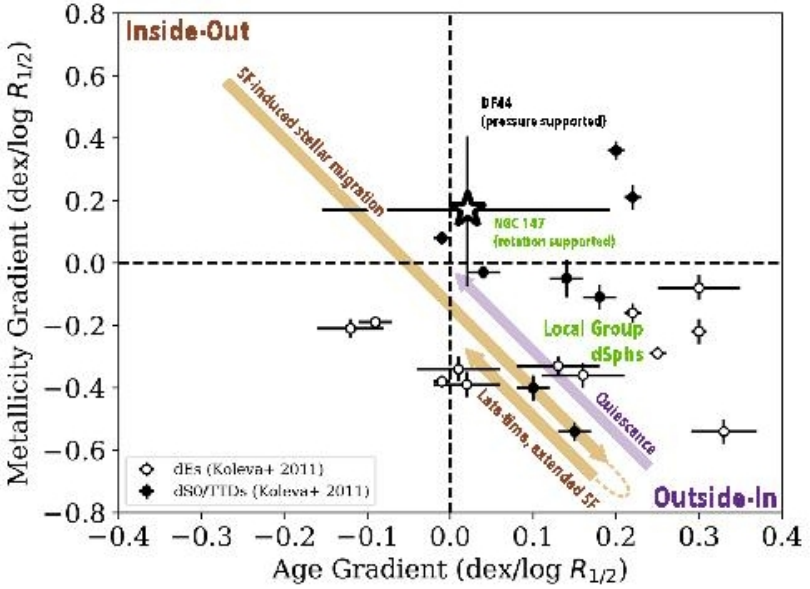


Figure 8. Comparing the age and metallicity gradients we measure for DF44 with the sample of dEs (open circles) and dS0s/TTDs from Koleva et al. (2011) (filled circles). In green text are objects which can only be qualitatively shown on this figure. The yellow ("inside-out") and purple ("outside-in") arrows show two general models for how age and metallicity gradients arise in dwarf galaxies. Both processes have been invoked to explain the gradients of the Local Group dSph population (i.e., positive age gradients and negative metallicity gradients: see text in Section 3 for more discussion and detailed references). Whether star formation proceeds in an inside-out or outside-in manner, the old age and the nearly flat gradients we measure for DF44 are not consistent with

Разбор сценариев

Отвергаются:

- High-spin halo
- SF feedback
- Обдирание в скоплении
- Обдирание приливом в группе
- Gas-rich dwarf-dwarf merger, и другие сценарии для карликов из FIRE
- И вообще все сценарии с продолжительным звездообразованием