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Peculiar Stellar Ages of the Peculiar Dwarf Galaxy NGC 5474

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ABSTRACT

Using deep, narrowband imaging of the nearby peculiar spiral galaxy NGC 5474, we present stellar age information across its disk and offset bulge. As shown in earlier work on M101, our narrowband filters measure age-sensitive absorption features such as Balmer absorption. We separate our study of NGC 5474 into its main disk containing its offset bulge, and the faint outer disk. We show that the main disk is relatively well-mixed in ages, showing no radial age changes. Meanwhile, the offset bulge is distinct from the main disk, showing only old ages. We explore the ages of the outer disk as a function of angle, showing that it is relatively young with the side towards M101 showing the youngest ages. We interpret this in the context of the M101-NGC 5474 interaction and the potential extragalactic nature of the offset bulge.

1. INTRODUCTION

The study of Local Group dwarf galaxies has revealed “outside-in” stellar population gradients: stars are, on average, more metal-poor and older outward (e.g., C. L. Riggs et al. 2024). However, dwarf galaxies that interact with their host or other dwarfs will likely modify the distribution of their stellar populations (L. Mayer 2010; E. L. Łokas et al. 2012). For this reason, it is important to characterize the stellar populations of interacting dwarf galaxies. We present the stellar age properties of the peculiar dwarf galaxy NGC 5474, a satellite of M101 (NGC 5457). NGC 5474 has likely interacted with M101 ∼300 Myr ago and may be interacting with a dwarf companion, often interpreted as an offset bulge (see R. Garner et al. 2025 and references therein) and offers an interesting case study to the effects of interactions on stellar populations in dwarf galaxies.

2. METHODS

In order to estimate stellar populations in NGC 5474, we utilize deep, wide-field narrowband photometry previously used to analyze the stellar populations of M101 (R. Garner et al. 2024). The data was collected at the 24/36-in Burrell Schmidt telescope; a full description of the data and data reduction can be found in R. Garner et al. (2022). Namely, we use the Hβ and [O II]λ3727 on-band filters as well as the adjacent off-band filters. These filters are sensitive to stellar absorption, whether that be the Balmer absorption or the slope of the blue continuum (R. Garner et al. 2024). In order to study the underlying stellar population, we identified H II regions in a continuum-subtracted Hα image and subsequently masked them, resulting in images devoid of emission.

Finally, we define three morphological environments: the bulge with a radius of $30''$ (1 kpc); the main disk, centered on the kinematic center of B. K. Rownd et al. (1994) with a radius of $90''$ (3 kpc); and the outer disk, centered on the kinematic center beyond the main disk out to $210''$ (7 kpc; see Figure 1). In order to maximize the S/N in our images, we bin the main disk and bulge in 3×3 pixel ($4'' \times 4''$ or 145×145 pc) blocks and the outer disk in 9×9 pixel ($13'' \times 13''$ or 450×450 pc) blocks. We calculate the equivalent width (EW) through these filters to explore age trends.

3. THE MAIN DISK

The bottom panels of Figure 1 show the Hβ and [O II] filter EWs, $\mathrm{EW}_{\mathrm{H}\beta}$ and EW_{3746}, of the main disk and bulge. The solid lines are exponential SFH models from R. Garner et al. (2024) created with CIGALE (M. Boquien et al. 2019):

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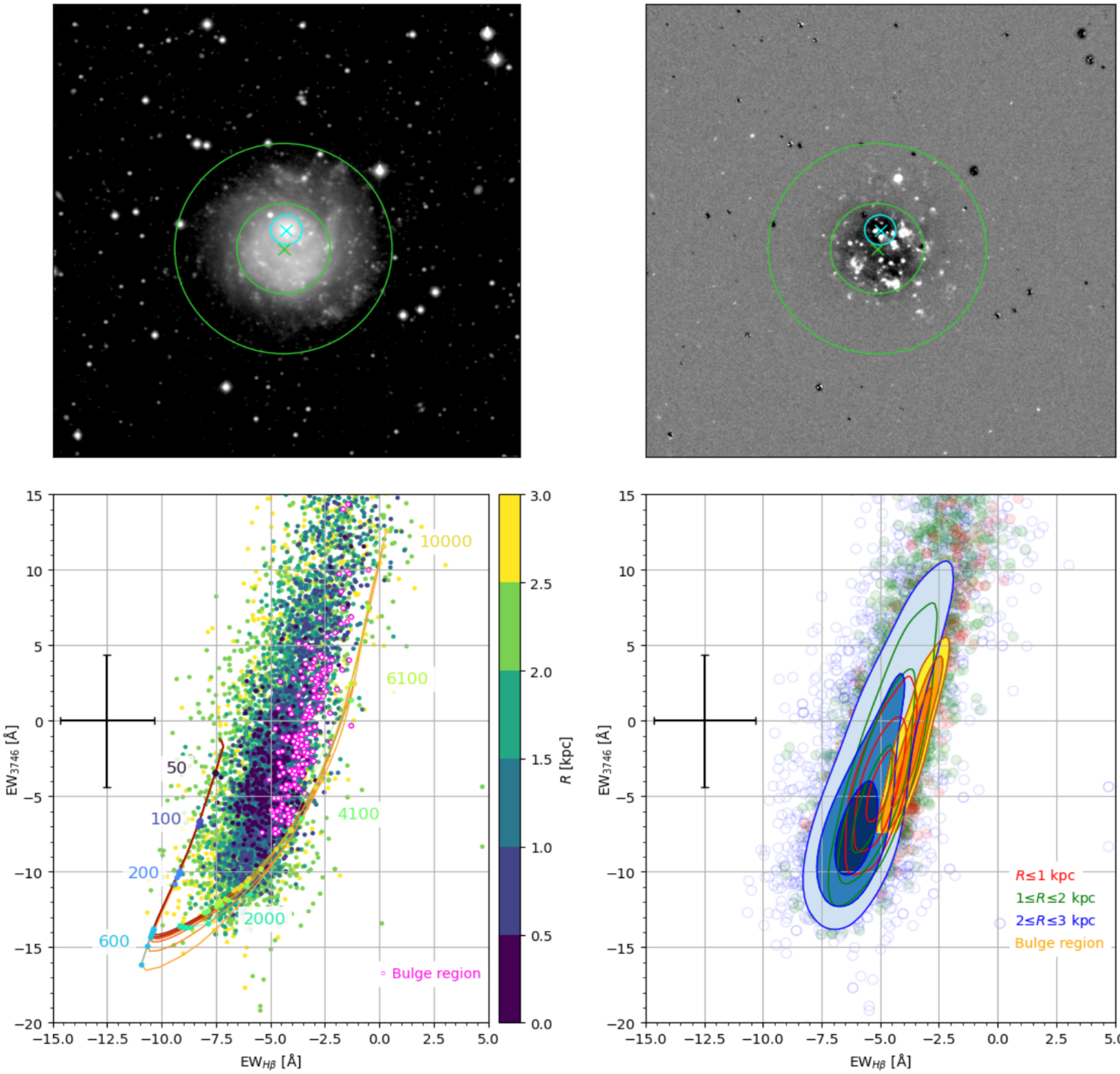

Figure 1. Top left: the broadband B image of NGC 5474 (J. C. Mihos et al. 2013). Top right: the narrowband continuum–subtracted Hβ image; white indicates emission and black indicates absorption. In both panels, the blue circle defines the bulge, the inner green circle defines the main disk and the outer circle defines the outer disk, both centered on the kinematic center (B. K. Rownd et al. 1994). Bottom left: the Hβ and [O II] EWs of the main disk and bulge. The main disk is colored by radial distance from the kinematic center. The lines are different modeled SFHs (see text). Bottom right: same as the bottom left, but with density contours in three radial ranges and the bulge. Characteristic errors are given to the left in each panel.

colored lines indicate different τ, while the colored points along the lines are the ages in Myr. We see that the bulge forms a coherent group of points along the right side of the plot, indicating a characteristically old population. This is consistent with other studies of its stellar populations (M. Bellazzini et al. 2020; G. Bortolini et al. 2024).

Meanwhile, the main disk is colored by radial distance from the kinematic center and spans the range between the bounds of the model tracks. There does not appear to be a radial trend in the stellar ages in the main disk. This is more easily seen in the lower right panel of Figure 1 where we plot three radial ranges with density contours. There is no change in the ages with radius, while the bulge is clearly distinct from the main disk. This suggests that the main disk is well-mixed. Dwarf galaxies do have short mixing timescales given their size (L. Mayer 2010; E. L. Łokas et al. 2012) and NGC 5474's interactions with M101 and its bulge might have aided this mixing.

4. THE OUTER DISK

With an interaction with M101 in mind, we investigated the faint outer disk of NGC 5474 to see if we could find any stellar age trends. We selected four angular wedges in the outer disk and looked for azimuthal trends in ages. We found that the southeast wedge had the oldest ages, while the northwest wedge had the youngest ages, with the remaining wedges having intermediate ages. The galaxy is more extended in the northwest direction (Figure 1), which is also in the direction of M101. This could explain the age trends in the outer disk, which are often more sensitive to interactions (J. C. Bird et al. 2012).

Facility: CWRU:Schmidt

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