Towards the Low-Mass Stellar Initial Mass Function of the Ultra-Faint Galaxy Boötes I

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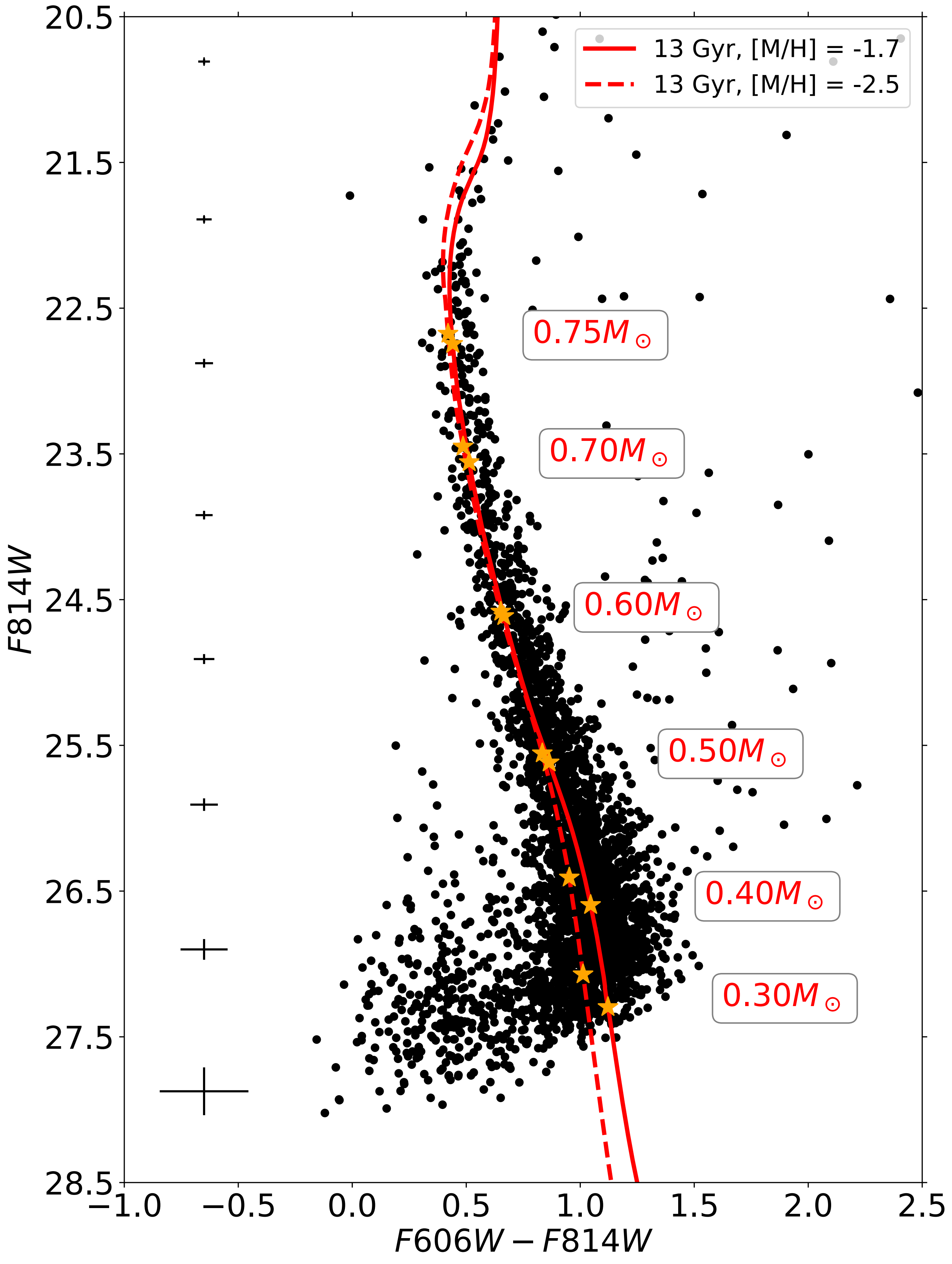
Abstract:

The stellar initial mass function (IMF) underpins our understanding of the baryonic content, star formation history, and chemical evolution of galaxies in the universe. Studies of the IMF in various environments in the Milky Way indicate that the IMF within the Galaxy is consistent with being invariant. When determining the stellar contributions to the total mass in the nearby ultra faint dwarf galaxies (UFDs), an IMF of the same form as the Milky Way's is typically assumed and integrated. However, it is unclear whether the IMF varies outside of the Milky Way. Should the IMF vary, what is the true stellar mass of these systems? In this work, we present a deep color magnitude diagram and new results on the low mass end of the luminosity function for Boötes I UFD to answer this question. These results were obtained utilizing new, deep Hubble Space Telescope Advanced Camera for Surveys (ACS) observations in the F606W and F814W bands, with photometry reaching down to I = 27.4 in the Vega magnitude system, and extending to a lower mass regime than previous investigations of Boötes I. The stellar population of Boötes I is universally old and very metal-poor (age > 12 Gyr, $\langle[Fe/H]\rangle \sim -2.5$, $\Delta[Fe/H] \sim 1.7$ [1,2]) and it likely underwent only a short epoch of star formation completed early in cosmic history, making Boötes I a fossil of star formation from an earlier era. Boötes I is the most luminous UFD ($M_v \sim -6$) and relatively nearby (distance ~60kpc [1]), and thus is an ideal target for the study of the faint end of the stellar luminosity function. At the depth of photometry reached by this work, the present-day mass function is very close to the initial mass function, and thus the IMF can be modeled from direct star counts after accounting for the presence of unresolved binary stars. Through this study of the low-mass population of Boötes I, we gain better understanding of star formation at high redshift.

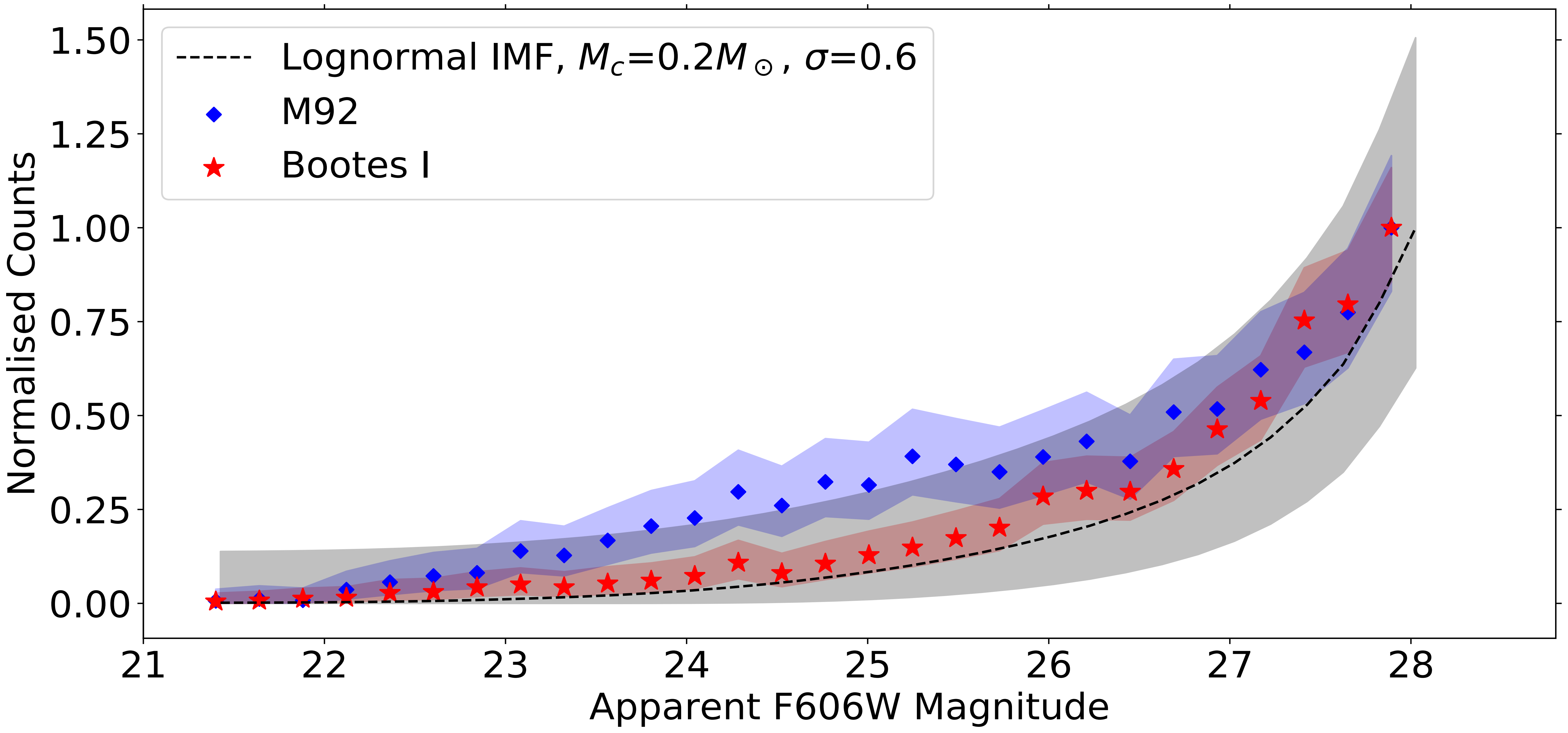
What is the Lowest Mass Star Reached in Boötes I?



Using the Dartmouth Stellar Evolution Database models [5], the 50% completeness limit of our photometry corresponds to a bit below 0.3$M_\odot$ solar masses. The depth we achieved is sufficient to determine the IMF using a broken power law or lognormal form.

How Does its Luminosity Function Compare to that of a Milky Way Globular Cluster with Similar Properties?

The present day low-mass stellar luminosity function, up to corrections for completeness, binarity, and possible dynamical effects, should directly translate to the IMF. We compare the low-mass luminosity function of M92 (age > 12 Gyr, mean $[Fe/H] \sim -2.3$) , which has been shown be consistent with the invariant Milky Way IMF, to that of Boötes I. We use photometry for M92 from the ACS Survey of Globular Clusters [3] shifted to the distance modulus of Boötes I, and determine the luminosity function at nine core radii (to reduce the effects of mass segregation). We plot this alongside the luminosity function of Boötes I and the luminosity function resulting from a Chabrier lognormal IMF [4] generated through the Dartmouth Stellar Evolution Database [5]. In each case, we plot the three sigma confidence interval as a shaded region, and scale the counts relative to the highest count value. In making this direct comparison, we ignore mass segregation in M92 and are incorrectly assuming that M92 and Boötes I have the same binary fraction, metallicity distribution, et cetera. However, we see hints that the low-mass IMF of Boötes I is consistent with a Chabrier IMF, which we explore further in our forthcoming paper. For details on the photometry presented here, see Filion et al 2020 (ApJ, submitted).



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SCHMIDT FUTURES

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