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ILT 1 WEEKS 1–2

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1. DETECTION OF POPULATION III STARS.

It is suggested that two distinct Population III classes may have existed: population III.1 and population III.2. The former, consisting of stars of $\sim 100 M_{\odot}$, and possibly going as high as $500 M_{\odot}$, is believed to be formed in dark matter halos at $z \approx 10$–30 which corresponds to the times of 0.1–0.48 Gyr after the Big Bang (Rydberg et al. 2013). There are models (Tornatore et al. 2007) that indicate on the later formation of population III.2 stars at $2 < z < 7$ due to that pockets of pristine metal-poor gas may have continued to exist at that time. Detection of stars of both classes requires observations at high redshifts. At the high end $z = 30$, even a 1000 $M_{\odot}$ star would have an AB magnitude of $m_{AB} \sim 36$. This is beyond photometric performance for existing telescopes and even for the NASA's upcoming premier 6.5 m *James Webb Space Telescope, JWST*, scheduled for launch in 2018 – see figure 1. It is worth mentioning that spectroscopic performance is generally lower, e.g. for *JWST* low resolution ($R \sim 100$) spectroscopy is limited to $m_{AB} \sim 26$. However it is assumed *JWST* will still be capable of detecting population III stars with several techniques:

1. Via detection of super star clusters or dwarf galaxies made of population III stars (Gardner et al. 2006).

2. Via detection of type II supernovae with population III progenitors, peaking brighter than $m_{AB} \sim 27$ (Gardner

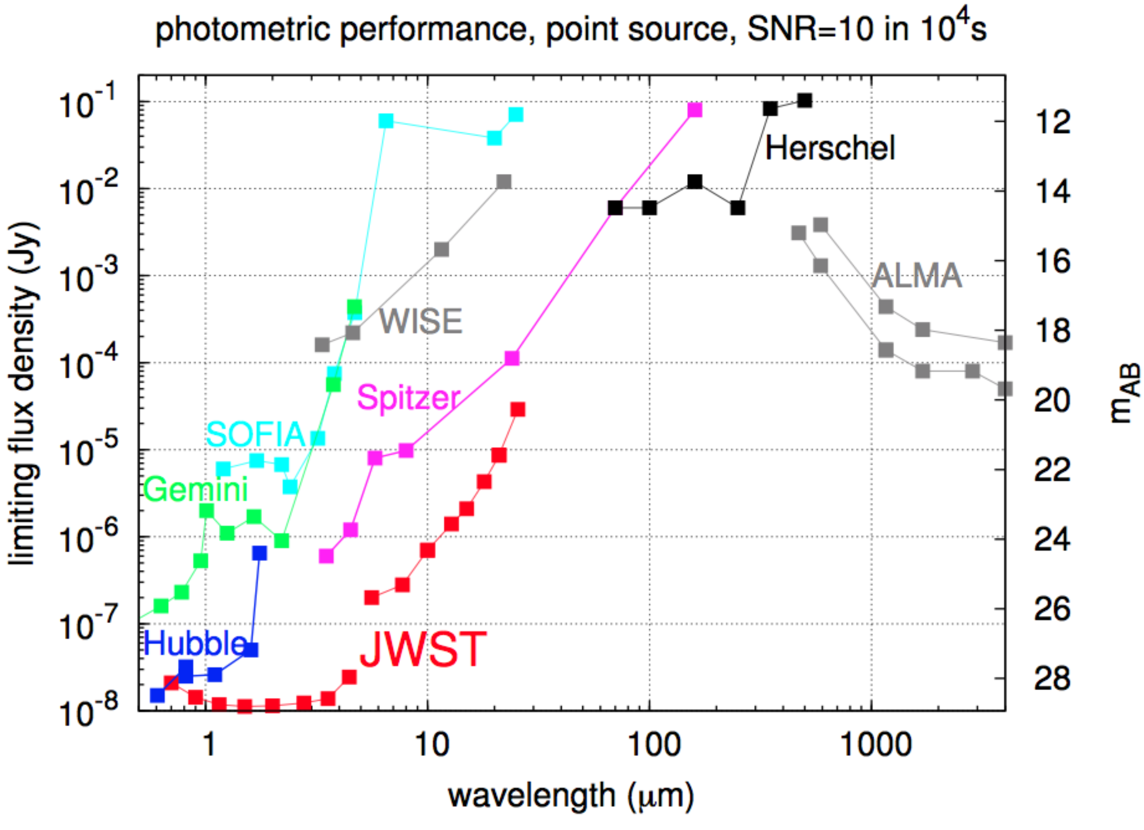

Fig. 1.— Photometric performance of various observatories. Red points show required sensitivities for the *JWST* instruments NIRCam (0.6–5 micron) and MIRI (5–28.3 micron). *Hubble* points are for the WFC3, ACS, and (reddest point) NICMOS instruments on *HST*. *Gemini* points are for the GMOS and NIRI instruments. *Spitzer* points are for the IRAC and MIPS instruments on *Spitzer*. *SOFIA* points are the predicted performance of the FLITECAM and FORCAST instruments. *Herschel* points are for PACS and SPIRE. *ALMA* points are shown at two configurations: Cycle 0 array (top curve), and final (lower curve.) Data from *http://www.stsci.edu/jwst/science/sensitivity.*

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et al. 2006). Expected numbers of events range from 4 to 2500 yr^{-1} deg^{-2}. At $z = 20$ predicted brightness of population III SNe is $m_{AB} \approx 26$

3. Direct detection through a powerful gravitational lens by a foreground galaxy (Rydberg et al. 2010).
4. Detection of pair instability supernovae (PISN) can imply existence of population III stars, with ~ 0.2 population III PISN predicted to be visible per each *JWST* field of view at any time (Hummel et al. 2012). The brightest PISNe should be detectable out to $z \sim 25$.
5. Models show that population III stars are expected to have left significant level of diffuse radiation, shifted today into the IR domain. These imprints in the cosmic infrared background (CIB) should be detectable at 3.6 μm (Kashlinsky 2006).

There are other indirect ways to probe the properties of population III stars. This includes detection of 21-cm H II emission from ionized hydrogen cloud produced by dead population III star. It is believed those stars are bright sources at 21-cm wavelength. This could be a potential target for the upcoming *Square Kilometer Array* scheduled for initial observations in 2020. The same instrument may be used to detect massive rapidly rotating population III.1 and III.2 stars producing collapsars and, thus, super-energetic γ-ray bursts (GRBs) (de Souza et al. 2011).

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