Compact [O III] Emission-line Regions ("Green Seeds") in Hα Emitters at Cosmic Noon from JWST Observations

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ABSTRACT

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We present a rest-frame optical, spatially resolved analysis of more than 100 Hα emitters (HAEs) at z ∼ 2.2 in the ZFOURGE-CDFS field using NIRCam imaging from the JWST Advanced Deep Extragalactic Survey. The ultradeep, high-resolution data give us maps of the resolved emission-line regions of HAEs with stellar mass ranging from 10 8 M e to 10 10 Me . An [O III] emission-line map of each HAE is created from the flux excess in the F150W filter, leading to the discovery of a population of kiloparsec-scale compact emission-line regions ("Green Seeds") with high equivalent widths (EW). We obtain a sample of 128 Green Seeds from 68 HAEs with rest-frame EW [O III] > 200 Å. Moreover, 17 of them have extremely large EW [O III] > 1000 Å, suggesting the possible Lyman continuum leakage from these emission-line regions. Embedded within the host galaxy, many Green Seeds correspond to UV star-forming clumps and H II regions, indicating elevated starburst activity in them, with specific star formation rates several times higher than that of the host galaxy. Based on theoretical frameworks, Green Seeds are expected to be formed through gravitational disk instability and/or galaxy mergers. Considering the stellar masses of Green Seeds, we speculate that high-mass Green Seeds may migrate toward the galactic center to build the central bulge, while low-mass Green Seeds are easily disrupted and short lived. Besides, we propose that some Green Seeds could be the progenitors of globular clusters or ultracompact dwarf galaxies observed in the local Universe.

GALAXY SAMPLE AND MEASUREMENTS

We have identified ~1300 HAEs at z~2.3 from the ZFOURGE survey in Chen+2024. The sample is selected from the flux excess in the broad-band Ks filter with a simultaneous measurement of [OIII] and [OII] from the flux excess in ZFOURGE medium band filter. We use the NIRCam images from JADES survey (overlapping with ZFOURGE-CDFS field) to further investigate their morphologies. Interestingly, we find many of the z~2.3 HAEs contains compact [OIII] emission-line regions (EW > 200Å), which we give the name of "Green Seeds".



Fig 1. *The composite rest-frame RGB (F115W+F150W+F277W) images of 30 sample HAEs contains "Green Seeds". Yellow circles in each panel represent the "Green Seeds" with S/N > 2.5, while white squares are those with S/N < 2.5. The galaxy ID in the ZFOURGE survey are marked in the upper-right in each panel with the host galaxy properties including stellar mass, SFR labelled.*

The flowchart to identify the "Green Seeds" (EW > 200Å, S/N > 2.5)

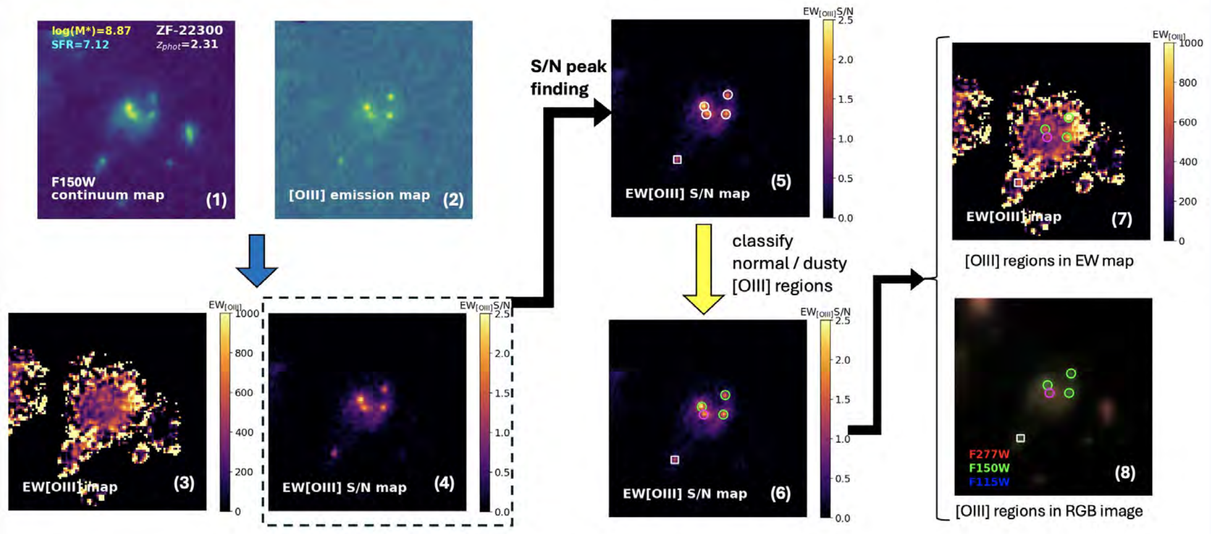


Fig 2. *We suppose a linear relation of the stellar continuum between the F115W and F277W filter and construct the continuum map. Then the residual image subtracted to the F150W image would be the [OIII] emission line map. Based on these two images, we extract the EW[OIII] and EW[OIII] S/N map of each HAEs. The "Green Seeds" in each panel are identified from a peak finding algorithm on the EW[OIII] S/N map.*

"Green Seeds" vs. Local HII Regions

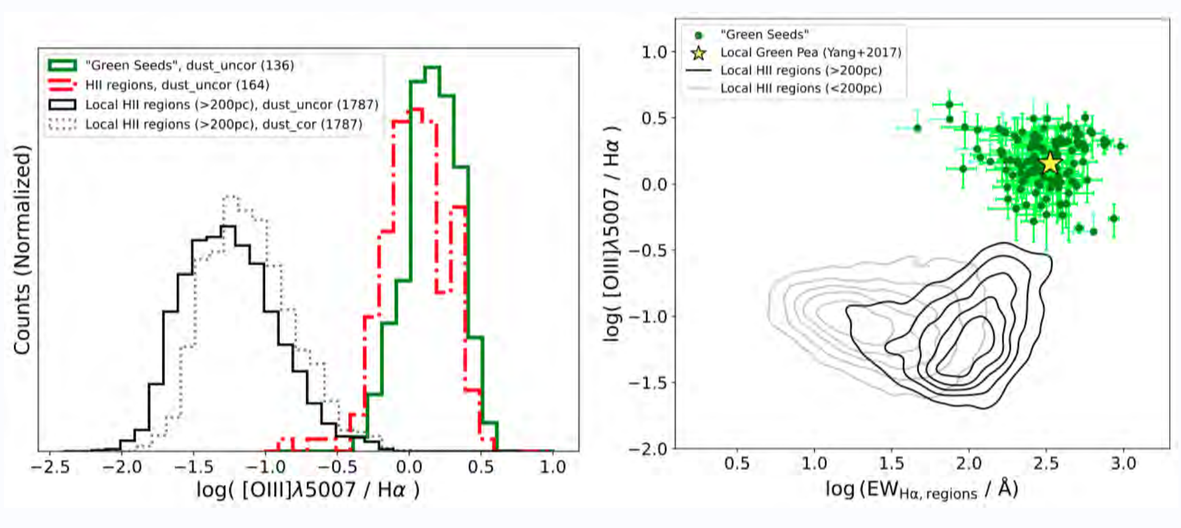


Fig 6. *Left: The [O III]λ5007/Hα ratios for Green Seeds, HII regions (using the same technique but on F200W image) at z ∼ 2, and local H II regions (>200 pc) from the PHANGS-MUSE survey. Right: Relationship between EWHα and [O III]λ5007/Hα ratios for Green Seeds distributed as green circles. Local H II regions with sizes > 200 pc (<200 pc) are represented by black (gray) contours.*

"Green Seeds" properties

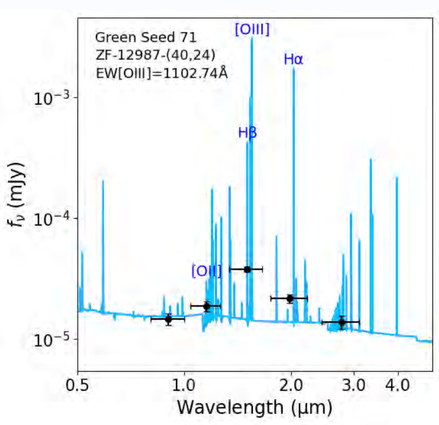


Fig 3. *Example SEDs of Green Seeds. Green Seeds favor young stellar populations with low dust attenuation.*

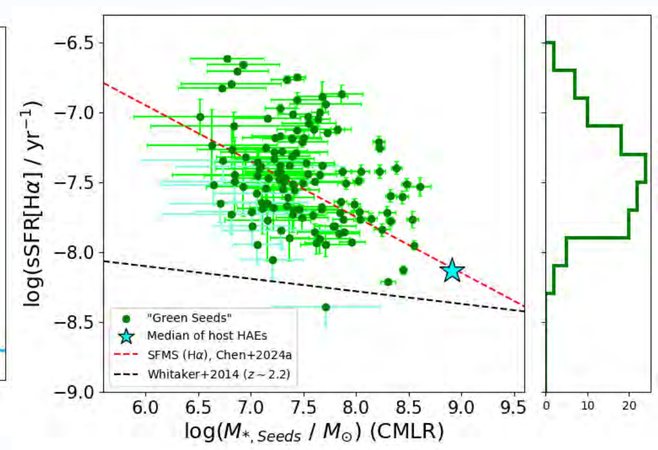


Fig 4. *Green Seeds have a much higher sSFR by ∼0.6 dex compared to their host galaxies.*

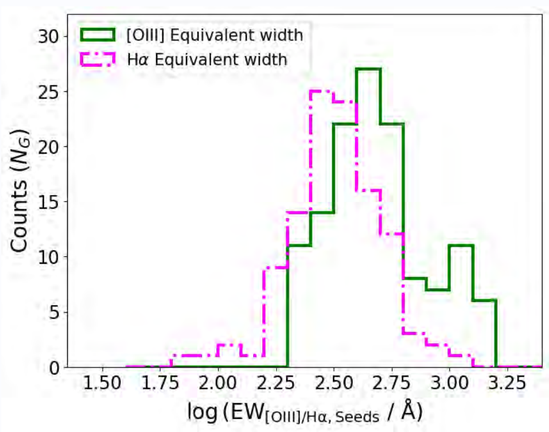


Fig 5. *The [O III] and Hα EWs for Green Seeds. The median equivalent width of EW[O III] = 452Å and EW Hα = 320 Å, respectively.*

"Green Seeds" vs. UV Star-forming Clumps

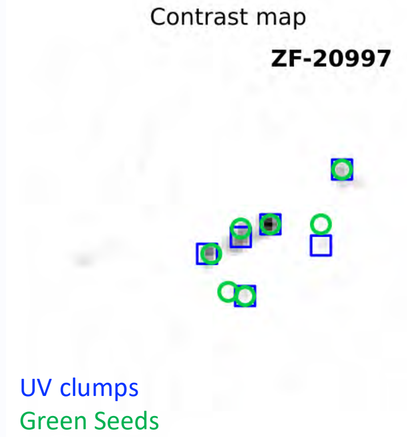


Fig 7. *The UV stellar continuum clumps are identified from the contrast (original-smoothed) F090W image.*

More than one third of Green Seeds are "off-peak" relative to UV star-forming clumps which could be explained by differences in the timescales of star formation or dust attenuation or ionized gas outflows driven by star formation feedback.