KICC Workshop 2017 -

Emission Line Galaxies with MOS: from cosmic noon to the reionization era

Ly-alpha Emitters with Intense [OIII] Emission: Analogs of Galaxies in the Reionization Era?

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Lya Emitters (LAEs) as Probes of Cosmic Reionization



Nebular properties of LAEs are Key for understanding galaxies in EoR

Rest Optical Nebular Properties characterizing Hot ISM

Nakajima&Ouchi 2014

Metallicity (*Z*) 12+log(O/H) Sensitive to R23-index

Ionization parameter (*qion***)**

Ionizing photons / gas Sensitive to [OIII]/[OII]



Higher ionization parameter is found in less chemically enriched galaxies

Redshift Evolution of Metallicity and Ionization parameter



See also Shapley+2015 Refer to talks by A. Strom, R. Sanders, T. Jones

Redshift Evolution of Metallicity and Ionization parameter



Nakajima+ 2016

See also Shapley+2015 Refer to talks by A. Strom, R. Sanders, T. Jones

Precise Characteristics of LAEs ?

Our Work

Keck/MOSFIRE H+K Observation Identifying [OIII]+ from 15 z=3-4 LAEs and LBGs



Nakajima+ 2016

Result on R23-032 Diagram

LAEs' Exceptionally High [OIII]/[OII] Ratio



See also Nakajima+2013, Nakajima&Ouchi 2014, Erb+2016

Result on R23-032 Diagram

LAEs' Exceptionally High [OIII]/[OII] Ratio



LAEs are lying above Local qion-Z relation

1) Young galaxies with **Hard ionizing spectrum ?**

2) Dominated by optically-thin HII-regions with High escape fraction of ionizing photons (fesc) ?

Discussion: O32 and Shape of Ionizing Spectrum

Harder Spectrum could increase O⁺⁺/O⁺



Discussion: O32 and Shape of Ionizing Spectrum

LAEs indeed present Harder Ionizing Spectrum in terms of ξion, Q(H⁰)/Luv



Nakajima+ 2016

See also Matthee+2016, Trainor+2016

Unlikely to fully explain O32 enhancement in LAEs

Discussion: O32 and Ionizing Photons Escape

Galaxies with Low N(HI) could have Reduced O⁺ regions



Nakajima&Ouchi 2014

Refer also to D. Schaerer's talk;

Jaskot&Oey 2014

Discussion: O32 and Ionizing Photons Escape

Galaxies with Low N(HI) could have Reduced O⁺ regions



Recent work that support our idea

LyC Leaking Galaxies present Very High [OIII]/[OII]



Nakajima+ 2016

See also Naidu+2016

Discussion: O32 and Ionizing Photons Escape

LAEs' high fesc are yet to be confirmed but suggested



Verhamme+17 (Iwata+2009, Nestor+2013, Mostardi+2013 added)

Nakajima+ 2016

Powerful SF Episode achieves Low N(HI) and high ξion, yielding exceptionally high O32 in LAEs.. ?

LAEs are ideal analogs of sources in reionization era

Low-mass, Low-metallicity, Young Hard Ionizing Spectrum Strong [OIII]

Highest [OIII]/[OII] in LAEs

Harder Ionizing Spectrum Higher Escape Fraction ... possibly

~ Powerful Star-Formation Episode

Our Future Studies

Hard Ionizing Spectrum *to be confirmed* with UV spectra High Escape Fraction of Ionizing Photons *to be directly checked* with HST

