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MUSE crowded field 3D spectroscopy in NGC 300

III. Characterizing extremely faint HII regions and diffuse ionized gas

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Context. There are known differences between the physical properties of H II and diffuse ionized gas (DIG). However, most of the studied regions in the literature are relatively bright, with $\log_{10} L(H\alpha)[erg/s] \gtrsim 37$.
Aims. We compiled an extremely faint sample of 390 H II regions with a median Hα luminosity of 34.7 in the flocculent spiral galaxy NGC 300, derived their physical properties in terms of metallicity, density, extinction, and kinematics, and performed a comparative analysis of the properties of the DIG.
Methods. We used MUSE data of nine fields in NGC 300, covering a galactocentric distance of zero to ~ 450 arcsec (~ 4 projected kpc), including spiral arm and inter-arm regions. We binned the data in dendrogram leaves and extracted all strong nebular emission lines. We identified H II and DIG regions and compared their electron densities, metallicity, extinction, and kinematic properties. We also tested the effectiveness of unsupervised machine-learning algorithms in distinguishing between the H II and DIG regions.
Results. The gas density in the H II and DIG regions is close to the low-density limit in all fields. The average velocity dispersion in the DIG is higher than in the H II regions, which can be explained by the DIG being 1.8 kK hotter than H II gas. The DIG manifests a lower ionization parameter than H II gas, and the DIG fractions vary between 15-77%, with strong evidence of a contribution by hot low-mass evolved stars and shocks to the DIG ionization. Most of the DIG is consistent with no extinction and an oxygen metallicity that is indistinguishable from that of the H II gas. We observe a flat metallicity profile in the central region of NGC 300, without a sign of a gradient.
Conclusions. The differences between extremely faint H II and DIG regions follow the same trends and correlations as their much brighter cousins. Both types of objects are so heterogeneous, however, that the differences within each class are larger than the differences between the two classes.

Point

- Warm ionized medium とも呼ばれている星間ガスの phase
- 銀河における電離ガス ⇒ HII region & Diffuse Ionized Gas
- DIG は late-type galaxy の Hα luminosity の 50% 近くにもなることもある
  ↳ DIG のエネルギー源，電離させている主体を知ることは重要．
  Hot low-mass evolved stars (HOLMES) や SNe shocks などが考えられる
- 先行研究での HII vs DIG 比較では bright HII region しか扱っていない
- VLT/MUSE で low-luminosity HII region をとらえて比較をしたい
  ↳ 9× 1′×1′ の IFU データをもちいて HII, DIG を extract した．

Results

- サンプルした領域はかなり低密度で electron density は HII, DIG それぞれ 100, ~20 cm^{-3} 程度．
- DIG の reddening はほぼ検出せず，dust がほぼないと思ってよい
- O3N2 index で測った metallicity は HII, DIG で差がなかった
- DIG の方が わずかに velocity dispersion が大きい (ΔT ~ 800 K 相当)
  銀河中心側で分散が大きいが Shock の寄与はしれない
- 各 field での $L(H\alpha)$ DIG/HII ratio は 42-72% 程度 (CJ は 15%)
- DIG は HII region にくらべて high excitation & low ionization の傾向
- ionization の trend は HOLMES の寄与を示唆．ただし shock も有意に効いていそう
- morphology を用いずに輝線比(だけ)で HII, DIG を分類するのはむずかしそう

Fig.1 Region Segmentation

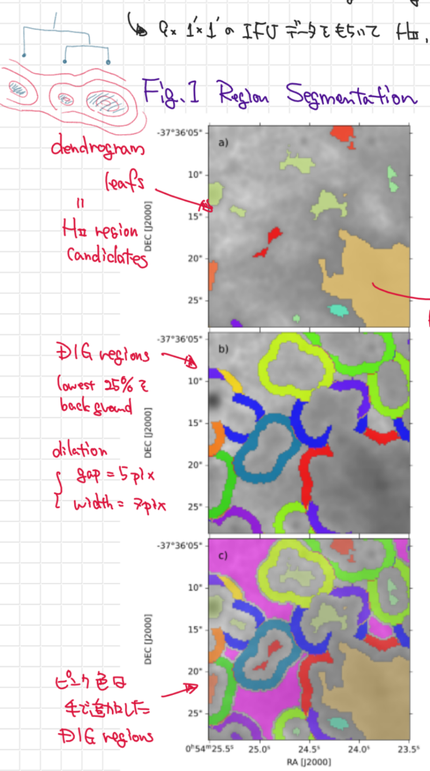
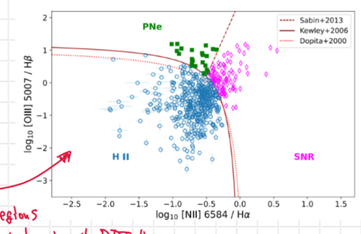
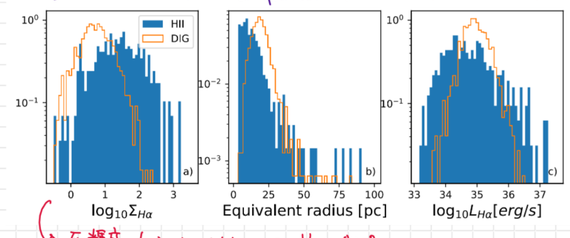


Fig.2. HII classification



HII regions extracted using the BPT diag.

Fig.4 HII & DIG comparison (HII: 390, DIG: 696)



面輝度，luminosity ともに comparable な分布

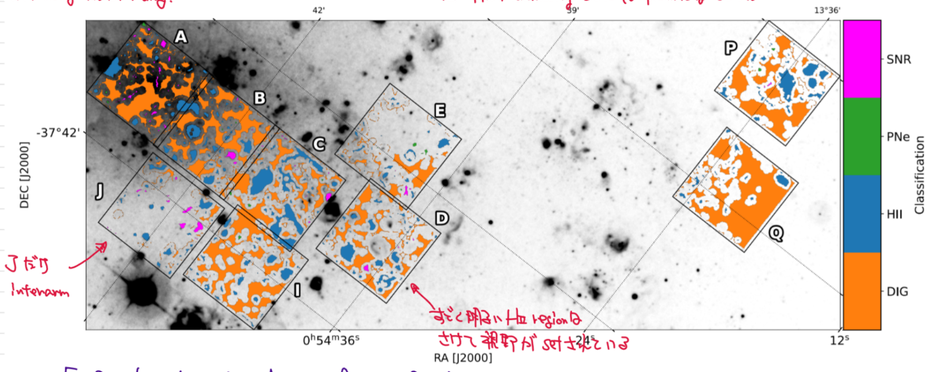


Fig 3. two-dimentional map of classifications

Fig.7. Electron density

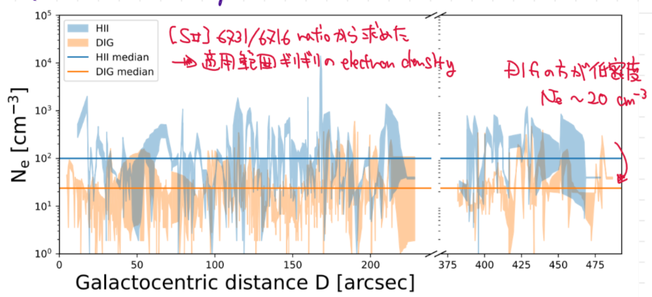


Fig.9 Metallicity by $O3N_2$ Index

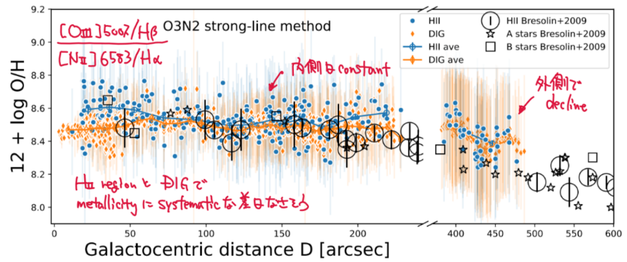
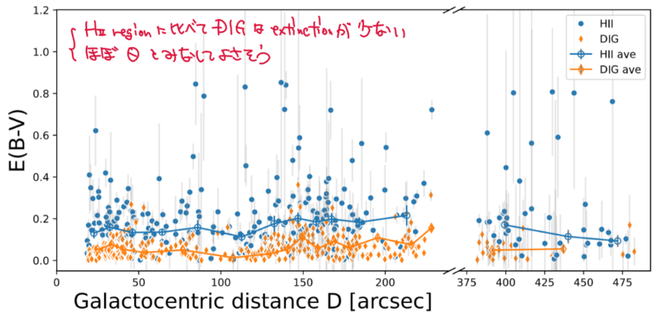


Fig.8 Extinction by Balmer Decrement



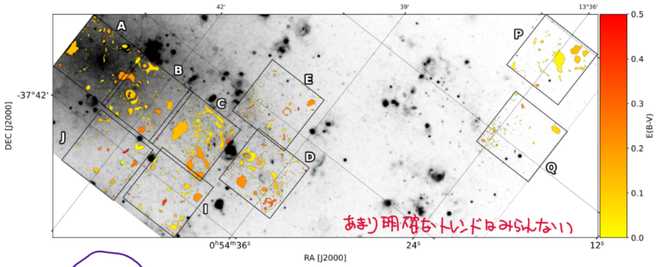


Fig 13. Sample Kinematics

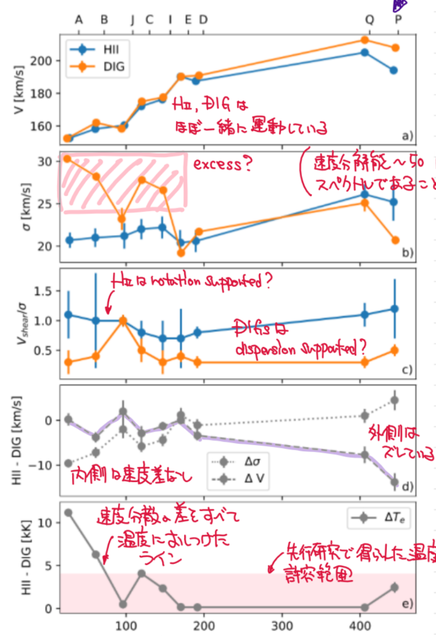
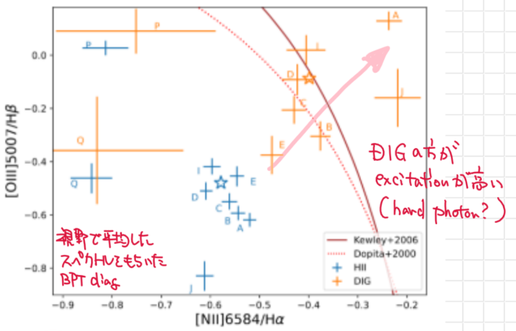
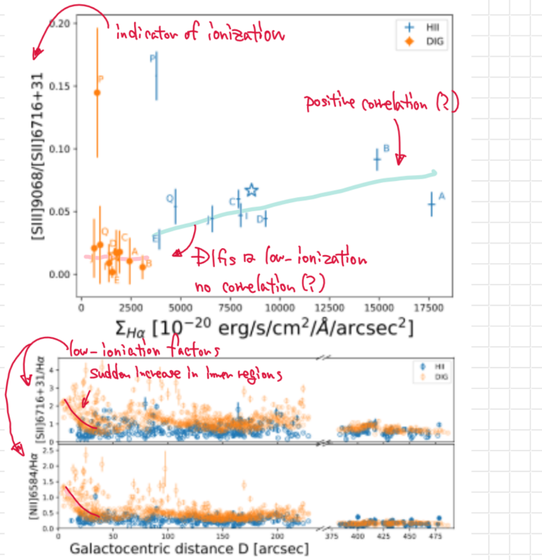


Fig.16 Evidence of HOLMES





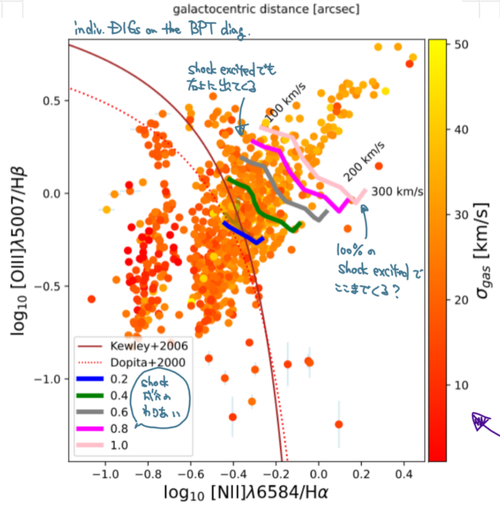


Fig.17 Shock Excitation of DIGs