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Faint  $z \sim 5$  quasars with  $M_{1450} \sim -23$  mag are known to be the potentially important contributors to the ultraviolet ionizing background in the post-reionization era. However, their number density has not been well determined, making it difficult to assess their role in the early ionization of the intergalactic medium (IGM). In this work, we present the updated results of our  $z \sim 5$  quasar survey using the Infrared Medium-deep Survey (IMS), a near-infrared imaging survey covering an area of 85 square degrees. From our spectroscopic observations with the Gemini Multi-Object Spectrograph (GMOS) on the Gemini-South 8 m Telescope, we discovered eight new quasars at  $z \sim 5$  with  $-26.1 \leq M_{1450} \leq -23.3$ . Combining our IMS faint quasars with the brighter Sloan Digital Sky Survey (SDSS) quasars, we derive, for the first time, the  $z \sim 5$  quasar luminosity function (QLF) without any fixed parameters down to the magnitude limit of  $M_{1450} = -23$  mag. We find that the faint-end slope of the QLF is very flat ( $-1.2$ ) with a characteristic luminosity of  $-25.7$  mag. The number density of  $z \sim 5$  quasars from the QLF gives lower ionizing emissivity and ionizing photon density than those in previous works. These results imply that quasars are responsible for only 10-20% of the photons required to completely ionize the IGM at  $z \sim 5$ , disfavoring the idea that quasars alone could have ionized the IGM at  $z \sim 5$ .

### [ㄱ GC-17] The fate of an infalling circumgalactic gas clump and the growth of the central massive black hole in a high-redshift quasar

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Since the discovery of SMBHs at  $z > 6$ , the growth spurt of a BH in a relatively short time—a few hundred Myr—has been a challenging topic for many observers and theorists. Super-Eddington accretion, major and minor merger have been compelling candidate mechanisms to account for such growth.

We introduce a passive scalar field to trace the infalling of circumgalactic gas clump onto high- $z$  quasar. With the scalar field, we investigate e.g. where the most of the gas clump eventually reside in the host galaxy and how much gas is accreted onto the central massive black hole. In addition,

we have studied the impact of thermal feedback of stars on the growth of black hole and the infalling gas. We will also discuss the future application of passive scalar field in e.g. minor and major mergers of high- $z$  quasar.

### [ㄱ GC-18] The Nature of Submillimeter Galaxies in the North Ecliptic Pole SCUBA-2 Survey

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Submillimeter galaxies (SMGs) have played an important role in the understanding of galaxy evolution and cosmic star formation history at high redshift because they are known as being located at  $z \sim 2$  and harbor a vigorous star formation. Therefore studying properties of SMGs can lead us to understand evolution of massive and actively star forming galaxies and distribution of cosmic star formation density. Recently we detected 548 SMGs near North Ecliptic Pole with JCMT/SCUBA-2 from the JCMT large program covering about  $2 \text{ deg}^2$  so far. To derive their physical parameters, we compiled a multi-wavelength photometry ranging from optical ( $0.3 \mu\text{m}$ ) to submillimeter ( $850 \mu\text{m}$ ) by cross-identifying counterparts at different wavelengths. In order to find counterparts, we used either VLA-1.4 GHz image and/or Spitzer/IRAC  $3.6 \mu\text{m}$ ,  $4.5 \mu\text{m}$  image. The number of SMGs with relatively robust counterparts is 349. In this talk, we present photometric redshifts, stellar mass, star formation rates, total infrared luminosity, and AGN fraction of these 349 SMGs derived through SED fitting analysis.

### [ㄱ GC-19] SCUBA-2 Observation of the JWST/GTO Time Domain Survey Field

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