

Upper limits on transmitter rate of extragalactic civilizations placed by Breakthrough Listen observations

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Search for Extra-Terrestrial Intelligence (SETI) has been conducted for more than sixty years, and no technosignatures have yet been identified. Most previous studies have focused on stars in our galaxy, and very few searches in the extragalactic Universe, where a much larger volume is available. Civilizations that can handle great energy harvested from a star or a galaxy are called a KII or KIII civilization on the Kardashev scale, respectively. Hypothetically, technosignatures from such advanced civilizations would also be extremely luminous, which can be detected by current radio telescopes even for distant galaxies. To explore a frontier of extragalactic SETI, we investigate the prevalence of such extragalactic civilizations possessing a radio transmitter, known as transmitter rate, based on the results from the Breakthrough Listen (BL) observations. We investigate the transmitter rate by considering the background galaxies in the field of view (FoV) of target stars during BL observations. The total mass of stellar systems in those background galaxies was statistically derived from a galaxy stellar mass function. Our results imply that less than one in hundreds of trillion extragalactic civilizations within 969 Mpc possess a radio transmitter above 7.7×10^{26} W of energy if we assume one civilization per one-solar-mass stellar system. In addition, we cross-matched the BL surveyed fields with the WISE×SuperCOSMOS Photometric Redshift Catalogue and derived the total mass of those galaxies for comparison. Our results set the strictest limits on transmitter rate at such a high energy, emphasizing the rarity of technologically very advanced civilizations in our Universe.

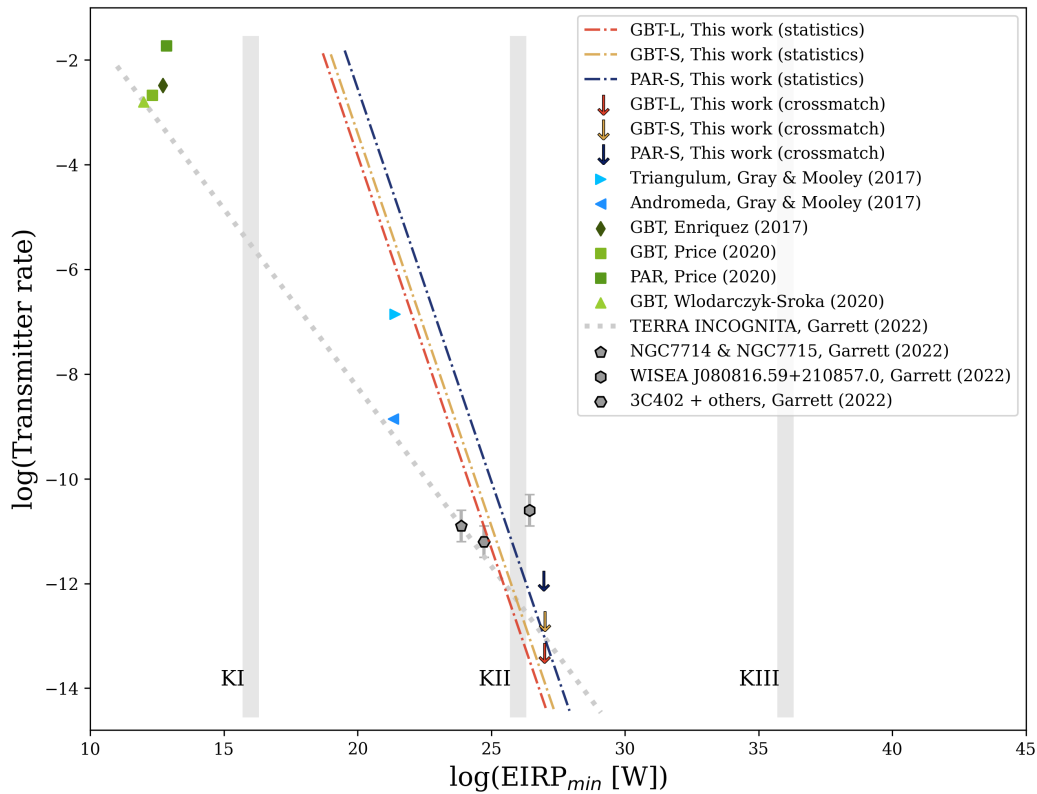


Figure 1. Upper limit on the transmitter rate as a function of $\text{EIRP}_{\min}$ in this work and previous studies.