Investigate the Effects of Active Galactic Nucleus on Star Formation Rate Through Cavity Energetics and SED Fitting

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The relationship between Active Galactic Nucleus (AGN) energy feedback and Star Formation Rate (SFR) has long existed as a debating topic with evidence showing positive, negative, and unrelated correlations. To reveal the underlying physics, this study carried out a joint investigation using both X-ray imaging spectroscopic analysis (a representation of AGN energetics) and multi-band SED modeling of samples of 58 and 20 targets, for which we applied a novel galaxy-cluster classification based on the cavity properties to offer an insight into AGN's influence on SFR in different environments. The image data are directly derived from the Chandra archive. After gaining corrected level 2 image data, beta model and unsharp masking techniques are applied to detect cavities embedded in the X-ray gas. The final sample consists of 58 systems with 129 cavities, which are classified into three categories and five subcategories: ML, MS (Multiple-cavity Large, Small), 1L, 1S (Single-cavity Large, Small), and D (Disorder) based on the definition of a natural AGN outburst. The cavities' spectra are then analyzed using the XSPEC version 12.11.1 to derive thermal properties for calculations of AGN energy and power. For 20 galaxies and BCGs of clusters in the final sample with sufficient photometry, this paper applied the SED fitting via CIGALE code and obtained 60 SFR data. By comparing the calculated energetics and obtained SFR, a stimulating effect of AGN input energy and power on SFR is found in the general group and the group (ML and MS), whereas there exhibits no correlation in the group (1L, 1S, and D). This study shows that the relationships between AGN and SFR are varied in different environments, suggesting that only AGN with natural outbursts has an enhancing impact on SFR.