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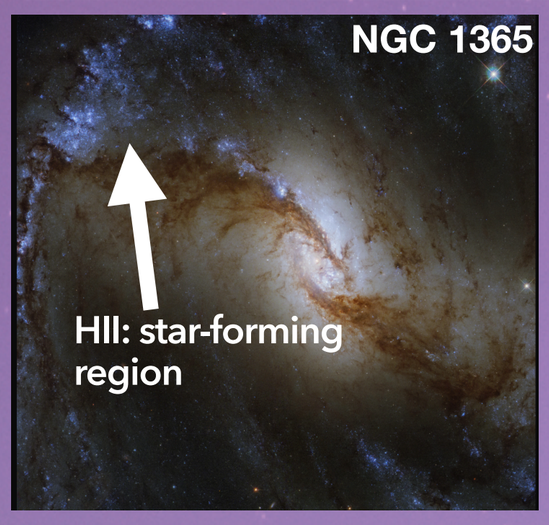
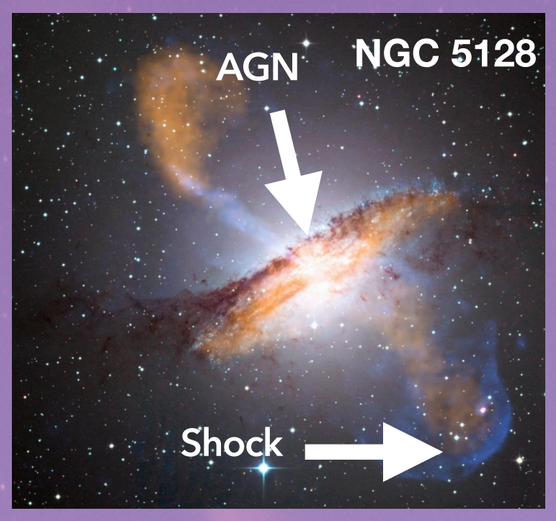
Separating Star Formation, AGN, and Shocks

Peixin Zhu, Lisa Kewley, Ralph Sutherland

ASTRO 3D · Australian National University · Harvard · Center for Astrophysics | Harvard & Smithsonian

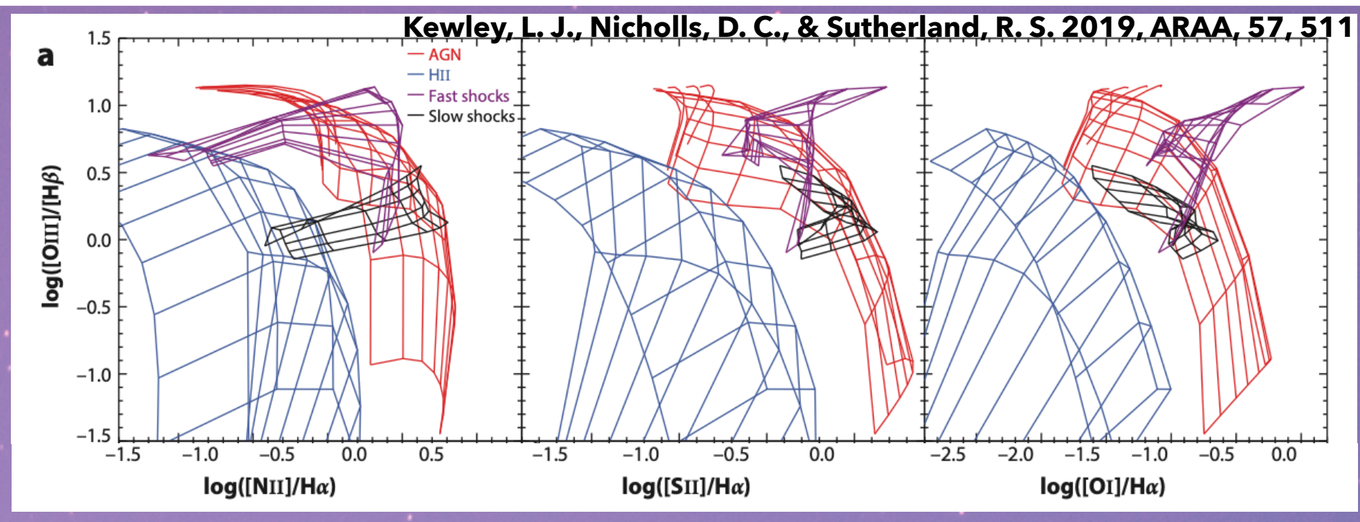
1. Star formation, AGN, and shocks present in galaxy





- Multiple excitation sources are known to exist in active galaxies, including the formation of bright O and B stars, actively accreting black holes, shocks, and diffuse ionized gas.
- All of these mechanisms contribute to the emission lines in the galaxy spectrum. A major challenge in galaxy studies that rely on emission lines is properly disengaging the mixture of different excitation sources.

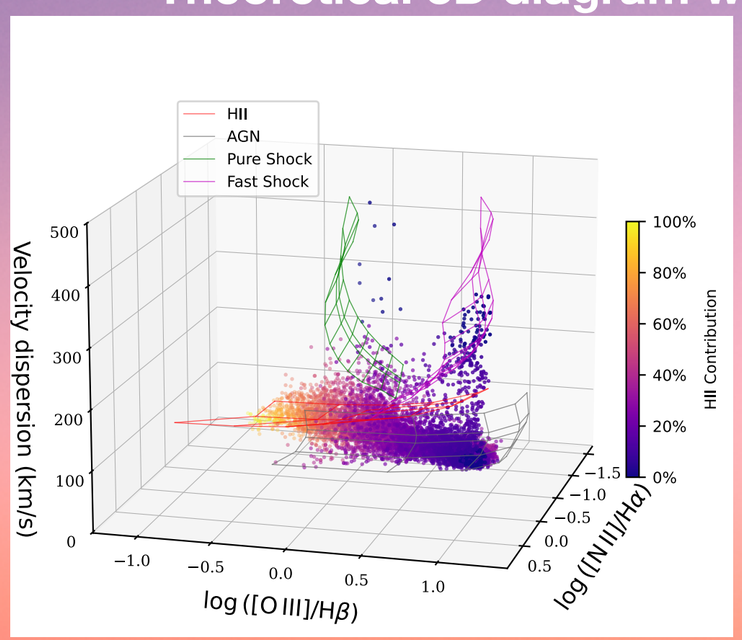
2. HII, AGN, and shocks mixed on BPT/VO diagrams

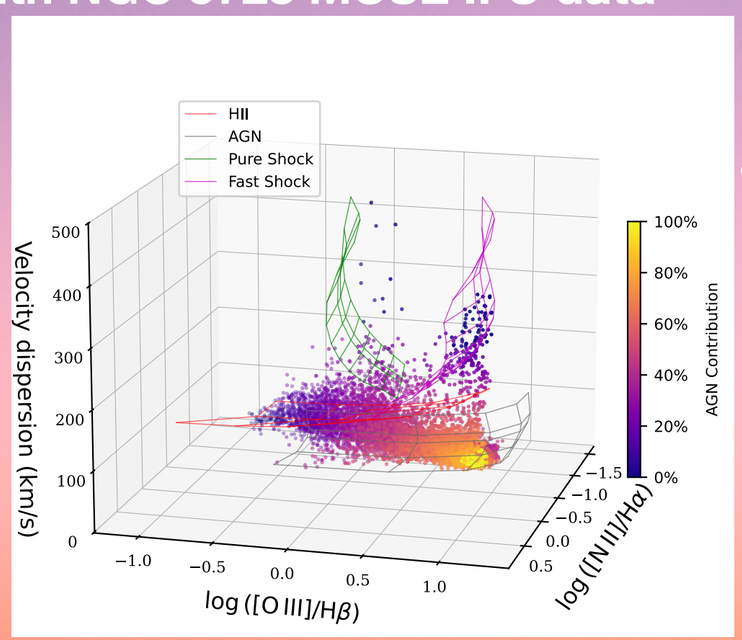


- Separating the mixture of excitation sources within a galaxy is made possible by wide-area and high-spatial- resolution integral field unit spectroscopy (IFU).
- With IFU data, in the case where only two excitation sources (star formation and AGN, or star formation and shocks) are present, separation can be performed on two-dimensional (2D) optical diagnostics diagrams
- However, accroding to observations and theoretical models, shocks can mimic AGN emission lines on the standard optical diagnostic diagrams, making it difficult to distinguish shock from the AGN on the 2D optical diagrams as shown above.

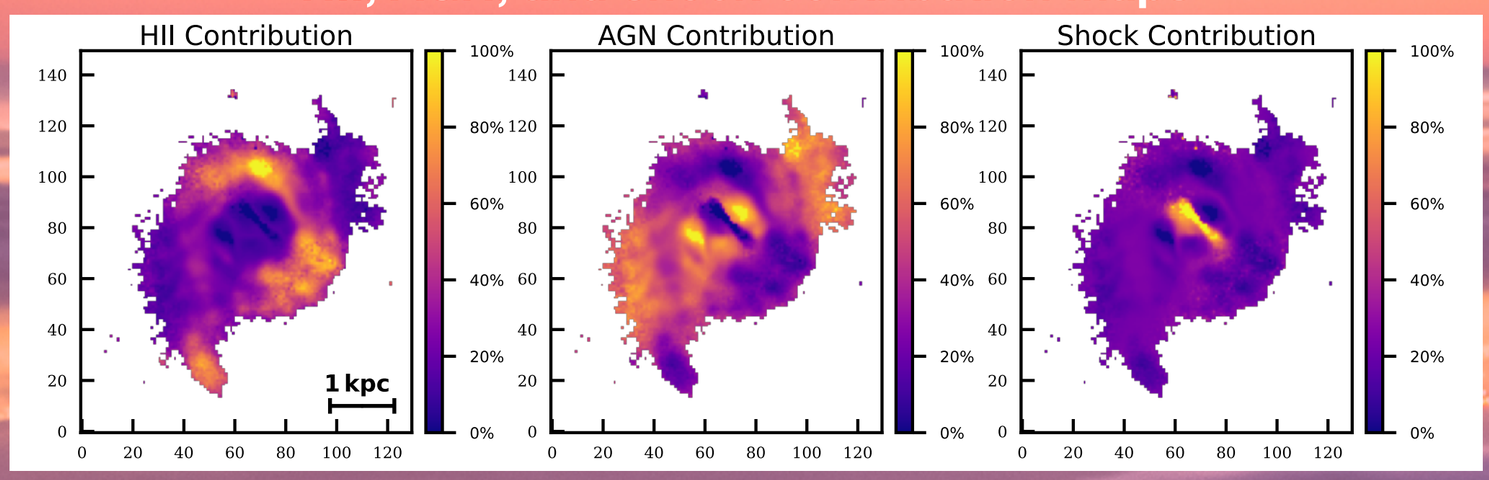
3. Theoretical 3D diagram can separate HII, AGN, and shocks with galaxy IFU data

Theoretical 3D diagram with NGC 5728 MUSE IFU data





HII, AGN, and shock contribution maps



- The HII contribution map reveals that star for- mation mainly happens in a ring structure surrounding the galaxy center with a projected radius of ~ 1 kpc in the sky plane, which is also suggested by Shimizu et al. (2019).
- The AGN contribution map shows that AGN excitation dominates a bicone struc- ture with a projected length of ~ 5 kpc in the sky plane from the southeast to the northwest direction, which is also suggested by Durré & Mould (2018); Shimizu et al. (2019).
- The shock contribution map reveals the presence of fast shock in the galaxy center with a disky shape perpendicular to the AGN bicone structure with a projected length of ~ 1 kpc in the sky plane. This is the first detection of fast shock in the center of NGC 5728.

- We use consistent HII model, AGN model, and shock models that are calculated by MAPPINGS version 5.2 and use the atomic data from the CHIANTI version 10 database for the lightest 30 elements.
- Utilizing the most up-to-date theoretical models, we find a 3D diagram that consists of emis- sion line ratios [N II] λ6584/Hα, [O III] λ5007/Hβ, and emission line velocity dispersion presents a remarkable ability in distinguishing HII, AGN, and shock models.

HII, AGN, and shock separated Hα maps