Isolating Sources of Ionization in Nearby Seyfert Galaxies

Garrett E. Polack[1] , D. M. Crenshaw[1] , B. Meena[1], M. Revalski[2], T. C. Fischer[2], J. Falcone[1]

[1]Georgia State University, Atlanta, GA, USA, [2]Space Telescope Science Institute, Baltimore, MD, USA

Abstract:

We present an ongoing research effort to identify ionization sources in nearby AGN using Apache Point Observatory (APO) and the Hubble Space Telescope (HST). We measure emission line ratios along the spatial extents of the narrow line region (NLR) using spectra from APO's Dual Imaging Spectrograph (DIS) and HST's Space Telescope Imaging Spectrograph (STIS). The spectra reveal prominent emission lines of ionized gas that can be primarily attributed to star formation or AGN ionization. We construct BPT diagrams and compare with HST color images to isolate these regions and determine their connection to the kinematics of the outflowing gasses. When combined with our ongoing study of mass outflow rates, these efforts will help further our overall goal of determining the effectiveness of AGN feedback on their host galaxies.

Introduction

- Emitted radiation from nearby active galaxies have shown to primarily be either the result of radiation from accretion disks around supermassive black holes at the center of AGN or the result of star formation in the host galaxy.
- We present two of our targets: NGC 1667, a Seyfert 2 galaxy with observed redshift of z = 0.01517 (319 pc/"), and NGC 4051, a Seyfert 1 galaxy with z = 0.00234 (53 pc/") (Verheijen & Sancisi, 2001).
- APO's DIS observations (four position angles for NGC 4051 and three for NGC 1667) were taken using B/R1200 gratings (resolving power R ~ 2000) with slit width = 2". HST spectra were obtained from MAST archive.

Methodology

- We employ a multiple component Gaussian fitting routine (Fischer, T. C. et al. 2017, ApJ, 834, 30) to determine the wavelength centroid, width and peak flux of the strong [O III] emission lines gathered by DIS.
- We then use the resulting fit parameters as templates to obtain kinematics and flux ratios of all other lines and then separate components based on total flux.
- Finally we generate the BPT Diagrams for each slit position and utilize the ratio points and distance data to create ionization maps to overlay onto scaled HST images for visible comparison.

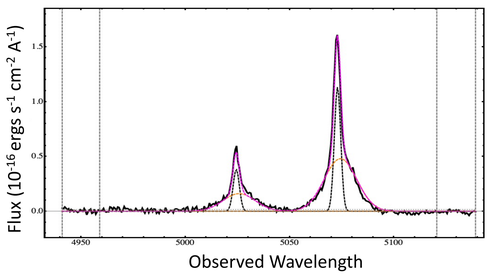
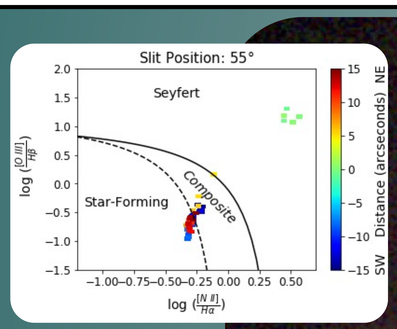
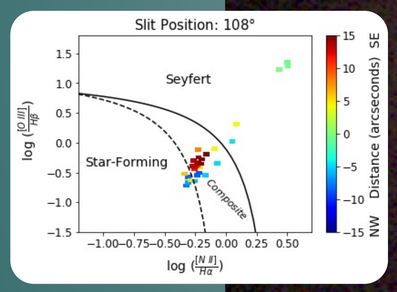
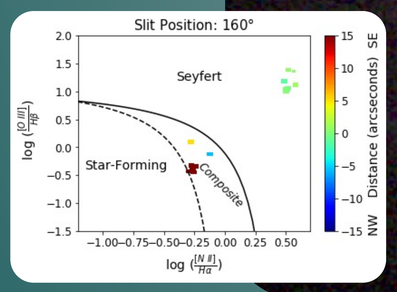


Figure 3: Example of a two component Gaussian fit to [O III] emission line with high flux component (blue), low flux component (red), and total fit (magenta)







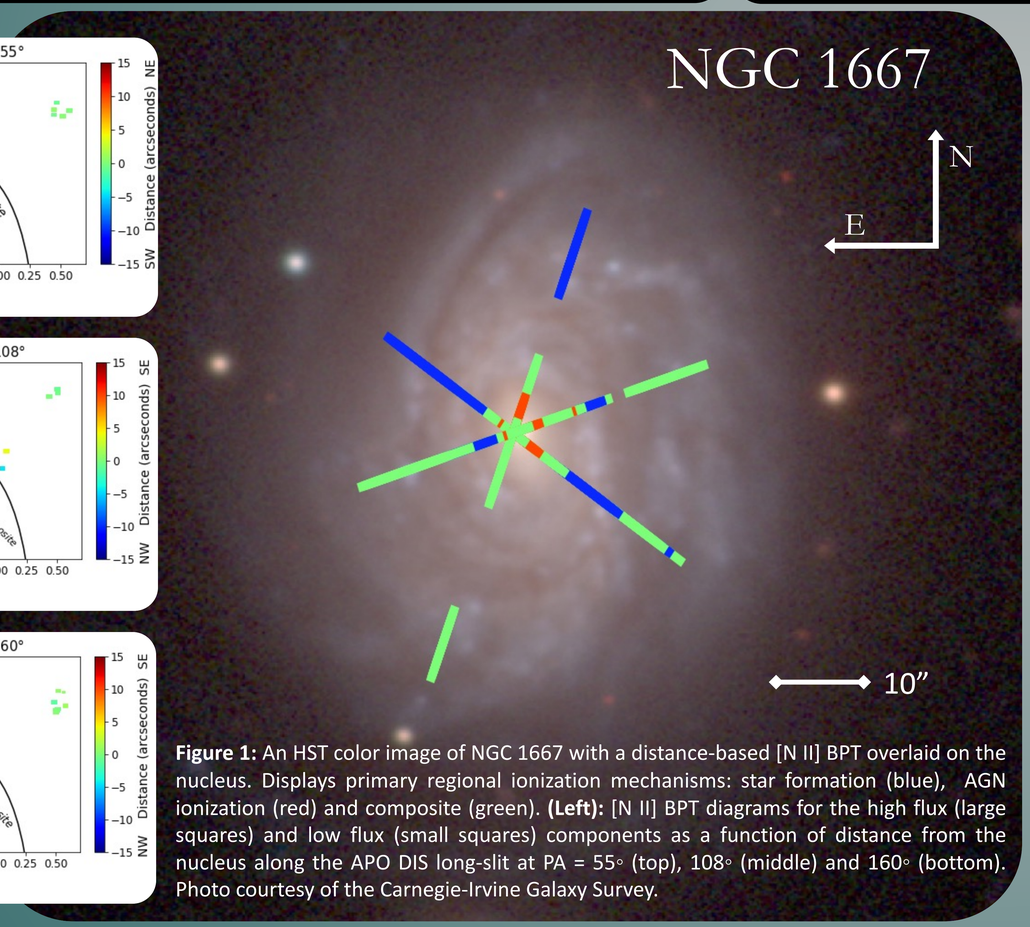


Figure 1: An HST color image of NGC 1667 with a distance-based [N II] BPT overlaid on the nucleus. Displays primary regional ionization mechanisms: star formation (blue), AGN ionization (red) and composite (green). **(Left):** [N II] BPT diagrams for the high flux (large squares) and low flux (small squares) components as a function of distance from the nucleus along the APO DIS long-slit at PA = 55◦ (top), 108◦ (middle) and 160◦ (bottom). Photo courtesy of the Carnegie-Irvine Galaxy Survey.

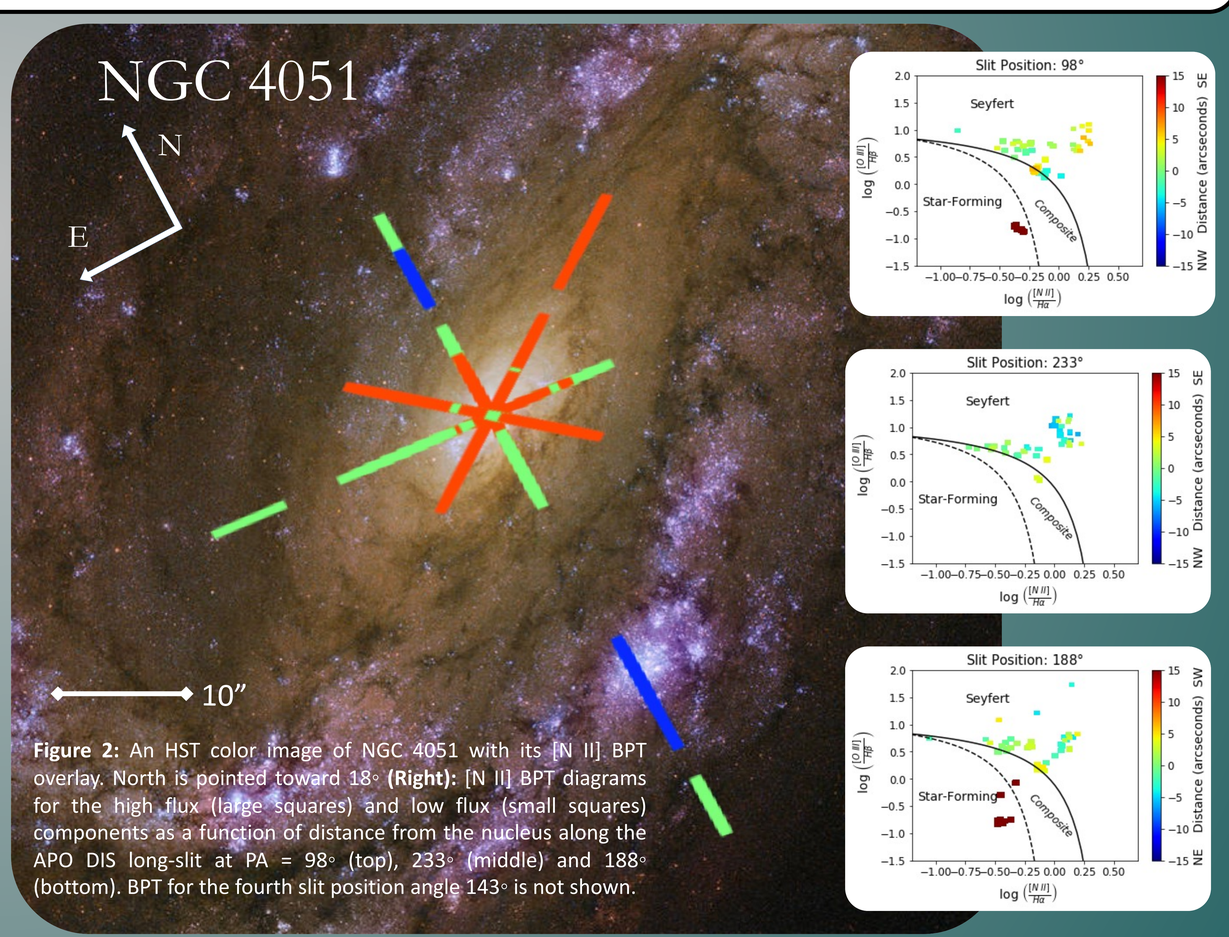


Figure 2: An HST color image of NGC 4051 with its [N II] BPT overlay. North is pointed toward 18◦ **(Right):** [N II] BPT diagrams for the high flux (large squares) and low flux (small squares) components as a function of distance from the nucleus along the APO DIS long-slit at PA = 98◦ (top), 233◦ (middle) and 188◦ (bottom). BPT for the fourth slit position angle 143◦ is not shown.

BPT Diagrams and Overlays

- We construct BPT (Baldwin, Phillips & Terlevich 1981) diagrams by determining ratios of the [O III] λ5007/Hβ λ4861 lines and comparing them with the ratios of [N II] λ6584, [S II] λ6716, λ6731, and [O I] λ6300 to H-alpha λ6563 for each kinematic component.
- We use the equations of Kewley et al. (2006) to determine if the primary source of the ionizing radiation at each location in the narrow-line region (NLR) is due to the central AGN (Seyfert or LINER), star formation, or a mixture of both (composite).
- We add a colorbar to each BPT diagram to indicate distance from the center of the observed slit.
- Using the above data, we generate ionization maps to show the primary source of ionization of the brightest flux component along each position angle in the NLR and into the extended NLR (ENLR) within the host galaxy

Results & Future Work

- Overlaid APO BPT diagrams correspond well to visual regions of star formation and AGN ionization displayed in the HST images (such as the star formation arm SW of the central AGN in NGC 4051).
- Identification of ionization mechanisms are consistent for the [N II], [S II], and [O I] ratios, providing confidence in our methodology.
- Additional work is needed to compare our ionization maps with spatially-resolved maps of the kinematics and mass-outflow rates generated by other members of our group.
- Similar overlays and analyses will be done for 6 additional Seyfert galaxies, including Mrk 78, NGC 1068, and Mrk 3 to compare spatially resolved mass outflow rates with the local ionization mechanisms.