Measuring the Stellar Kinematics of the Compact Galaxy NGC 1270

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Abstract

NGC 1270 is a nearby elliptical galaxy that is compact with a large stellar velocity dispersion for its luminosity. We observed NGC1270 in the near-infrared with the 10 meter Keck I telescope using the integral field unit OSIRIS with adaptive optics. This project focused on measuring the stellar kinematics as a function of spatial location within the galaxy. The galaxy is rapidly rotating with velocities of ±220 km/s and the galaxy has high stellar velocity dispersions ranging from 300-480 km/s. The rise in the velocity dispersion profile at the nucleus suggests this galaxy may host a very large supermassive black hole. Future work will include using these stellar kinematics to dynamically measure the black hole mass.

Introduction

It is widely accepted that supermassive black holes (SMBH) sit at the centers of most galaxies. These SMBHs range in mass from millions to billions of solar masses (10^6-10^9 $M_\odot$). Although the black hole's gravitational influence is limited to the central regions of galaxies, the masses of black holes surprisingly appear to be set by the large-scale properties of their host galaxy, suggesting that SMBHs and galaxies grow together. One such empirical relationship is between the black hole mass and the large-scale stellar velocity dispersion of the galaxy (M_{BH} - σ). In order to better understand the role that black holes play in galaxy evolution, we need more black hole measurements over a wider range of mass scales.

NGC 1270 is a small, elliptical galaxy located at a distance of 67 Mpc. It has a large-scale stellar velocity dispersion of 321 km/s and a K-band luminosity of 1.5×10^{11} $L_\odot$. Based on the M_{BH}-σ relation, NGC 1270 could host one of the largest black holes known to date.

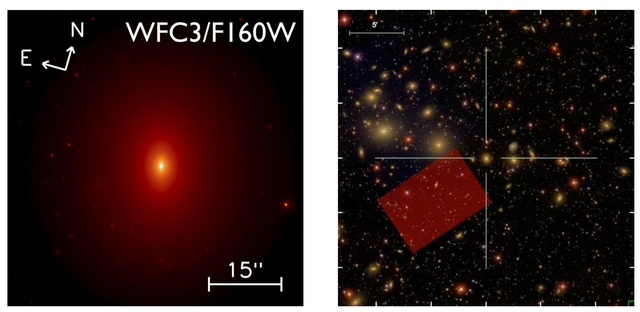

Figure 1. (Left) Image taken with *Hubble Space Telescope (HST)* using the Wide Field Camera 3 (WFC3) in the H-band. (Right) Optical image from the Sloan Digital Sky Survey (SDSS). NGC 1270 is located at the center, and the image is aligned such that north points up and east is to the left. NGC 1270 is a member of the Perseus cluster and given its distance, 1'' = 324 pc.

Observations

NGC 1270 was observed for a total of 3.7 hours using the 10 meter Keck I telescope located in Hawaii. All of the data were acquired in the near-infrared.

We used the OH-Suppressing Infrared Imaging Spectrograph (OSIRIS), which is an integral field spectrograph (IFS). An IFS provides a spectrum at each x and y spatial location, shown in Figure 2. A system known as adaptive optics (AO) assists OSIRIS. The use of AO allows us to correct for the blurring due to the Earth's atmosphere and therefore improves the angular resolution of ground-based telescopes. Our AO OSIRIS observations have an angular resolution of ~0.1'', similar to the angular resolution of *HST*. If NGC 1270 obeys M_{BH}-σ, we should be resolving the region where the potential from the black hole dominates.

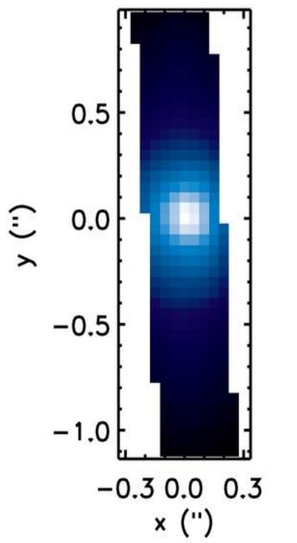

Figure 2. OSIRIS datacube of NGC 1270 taken with AO on the Keck I telescope. At each x and y location a spectrum was obtained. The long axis of the IFS is aligned with the galaxy major axis.

Measurements

With observations completed and the data reduced, we made measurements of the galaxy's stellar kinematics. We used the IDL program pPXF to make measurements at 51 spatial locations within the galaxy. This program compares the galaxy spectrum in each spatial bin to the spectra of template stars. The template star spectrum is shifted and broadened to match the observed galaxy spectrum, providing us with the best-fit velocity and velocity dispersion.

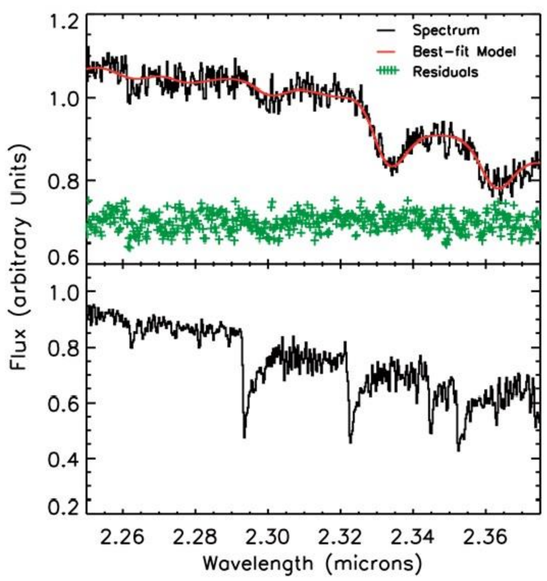

Figure 3. (Top) An example spectral fit (red) to the observed galaxy spectrum located at x= 0.08", y=-0.18" (black). The green pluses show the model residuals, and have been shifted by an arbitrary amount for plotting purposes. (Bottom) The spectrum of the template star used to measure the kinematics. This M0 III star was observed with OSIRIS as well.

Results

Figure 4 shows the velocity (v) and velocity dispersion (σ) plotted as a function of spatial location over the OSIRIS field of view. The v plot shows a clear red-shifted and blue-shifted side of the galaxy, indicating rotation. The σ plot shows a peak in velocity dispersion at the center. The closer you get to the center of the galaxy, the larger the velocity dispersion, suggesting the presence of a supermassive black hole. Typical errors on the kinematics are 18 km/s and 22 km/s for the velocity and velocity dispersion, respectively.

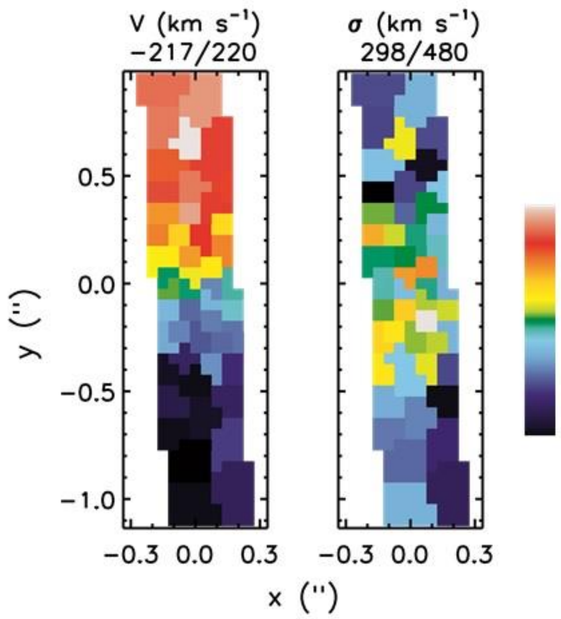

Figure 4. These plots show the stellar kinematics of NGC 1270. (Left) Plot of the velocity of the stars. Rotation is clear from the blue and red sections. (Right) Plot of velocity dispersion. The velocity dispersion increases from 300 km/s in the outer regions of the OSIRIS data to dispersions above 420 km/s at the center.

Conclusions

We use Keck/OSIRIS observations of NGC 1270 to measure the stellar kinematics. Our results show the galaxy is rotating quickly, that the galaxy exhibits large stellar velocity dispersions, and that the velocity dispersion increases at the nucleus. Future work will use these stellar kinematics to measure the mass of the central black hole through dynamical modeling methods. NGC 1270 could host one of the largest black holes known, and observations of such massive black holes are important for helping us to better understand the connection between black holes and their host galaxies.

Acknowledgments

This work was supported by NSF grant AST-1263034, "REU Site: Astronomical Research and Instrumentation at Texas A&M University. Data were obtained at Keck Observatory, operated as a partnership among Caltech, UC and NASA. The Observatory was made possible by the financial support of the W. M. Keck Foundation. We acknowledge the significant cultural role that Mauna Kea has had within the indigenous Hawaiian community. We are most fortunate to be able to conduct observations from this mountain.

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GMT

HETDEX — Hobby-Eberly Telescope Dark Energy Experiment — Illuminating the Darkness

LSST — Large Synoptic Survey Telescope

DARK ENERGY SURVEY