PLANETARY NEBULAE: THEIR EVOLUTION AND ROLE IN THE UNIVERSE
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The Stellar and Dark Matter Halo of NGC 5128

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Abstract. Extragalactic planetary nebulae (PNe) and globular clusters (GCs) are complementary tools for obtaining kinematic information on stellar populations in the outer halos elliptical galaxies. NGC 5128, as the nearest large elliptical ($D \sim 3.5$ Mpc), is an excellent galaxy for halo studies. We have now identified a total of 1140 PNe, and possess radial velocities for 736 PNe at distances out to 80 and 50 kpc along the photometric axes. There is clear evidence for kinematic axis twisting (triaxiality) in the PNe velocity field. The mass of NGC 5128 continues to rise out to 80 kpc, where $M(< 80\ \mathrm{kpc}) \sim 6.4 \times 10^{11}\ M_{\odot}$ with $M_{80}/L_B \sim 20$. We also conducted a new survey for GCs out to 50 and 30 kpc, and now have radial velocities for 188 GCs (125 new). Both the red and blue GC systems exhibit rotation. The red (metal-rich) GCs share a misaligned kinematic axis with the PNe. The success of this survey bodes well for future galaxy halo studies.

1. Introduction

NGC 5128 is a nearby (3.5 Mpc) post-merger elliptical, and is an excellent galaxy for kinematic and stellar population studies. We surveyed the halo for planetary nebulae (PNe) and globular clusters (GCs) using [OIII]λ5007 on- and off-band imaging in conjunction with broadband *UBVRI* imaging. Both PNe and GCs are useful kinematic tracers in galaxy halos where the surface brightness of the integrated light is too low for long slit spectroscopy.

2. Kinematics: The PN Velocity Field

Figure 1a shows the smoothed PN velocity field. We assume point symmetry in the potential, and reflect each PN through the origin while reversing the sign of its velocity, providing 1472 test particles. The zero-velocity contour shows a marked twist. This is one of the first cases in which the twist is clearly seen. The rotation in the inner regions primarily around the minor axis ("z-tubes"). Major axis rotation ("x-tubes") becomes more important in the halo. Kinematic-axis twisting is predicted for triaxial galaxies seen in projection, and is also seen in merger simulations.

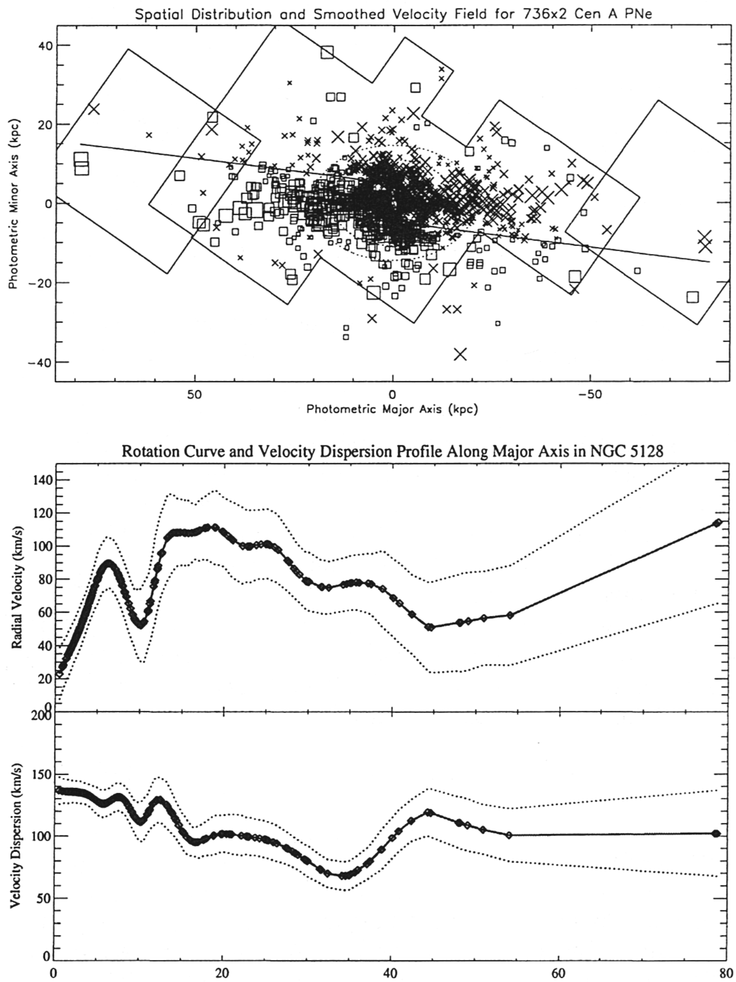

Figure 1. a) *NGC 5128 Smooth PN Velocity Field.* b) *Major Axis Rotation Curve and Velocity Dispersion Profile.*

3. Major Axis Dynamics, Mass, and Globular Clusters

We used 304 PNe along the major axis to create the rotation and velocity dispersion profile shown in Figure 1b. Assuming isotropic orbits, and using the spherical Jeans equation to fit for a mass, we obtain $M(< 80 \text{ kpc}) \sim 6.4 \times 10^{11}\ M_\odot$ with $M_{80}/L_B \sim 20$. We divided the 188 GCs into two groups—metal-rich and metal-poor—based on their $(V\!-\!I)$ color. We find that the metal-rich GCs have kinematics similar to those of the PNe, implying a common formation history.

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