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Extragalactic Globular Clusters & Their Host Galaxies

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M31's Disk System of Globular Clusters

Heather Morrison, Paul Harding and Denise Hurley-Keller

Dept of Astronomy, Case Western Reserve University, 10900 Euclid Ave, Cleveland OH 44106

Kathy Perrett

Department of Astronomy and Astrophysics, University of Toronto, Toronto, ON, Canada M5S 3H8

Abstract.
Globular cluster systems are often thought to be associated with violent formation events such as galaxy mergers or the formation of large bulges. However, formation in relatively ordered regions such as thin disks may also be an important process which has been overlooked.

Recent high-quality spectroscopic studies of the M31 globulars show that a significant number of the clusters projected on its disk belong to a rapidly rotating thin disk. This contrasts strongly with the Milky Way system, which is composed of a halo and thick disk system and has no known thin disk globulars. It is also likely that M31 has experienced no minor mergers since the globular cluster formation epoch, as such a merger would have heated the globulars into a thick disk system. The metallicity distributions of the disk and non-disk clusters are quite similar.

1. Introduction

M31 is a remarkably poorly understood system, despite its convenient location close to the Milky Way. In the past few years two high-quality kinematic studies of old population tracers (globular clusters and planetary nebulae (PN))have been published, with velocity errors of order 10 km/s. The globular velocities come from the study of Perrett et al (2002) and the PN data from Hurley-Keller et al (2004). These low velocity errors allow sensitive searches for systems with cold kinematics such as thin disks and dwarf galaxies. Here we describe our detection of a thin disk subsystem of globular clusters in M31.

2. Thin Disk Kinematics

The signature of disk kinematics is clear in a "position-velocity" plot such as Figure 1, where narrow strips parallel to the major axis are shown with velocity plotted against distance along the major axis. A completely cold disk with zero velocity dispersion will show a narrow diagonal line in this figure, with the only deviations due to variations in distance from the major axis (which affects the amount of circular velocity projected along the line of sight). A more realistic disk (such as those studied by Bottema 1993, whose properties were

used to construct the model panels in the Figure) will have additional velocity dispersion which will make the feature less narrow but still recognizable.

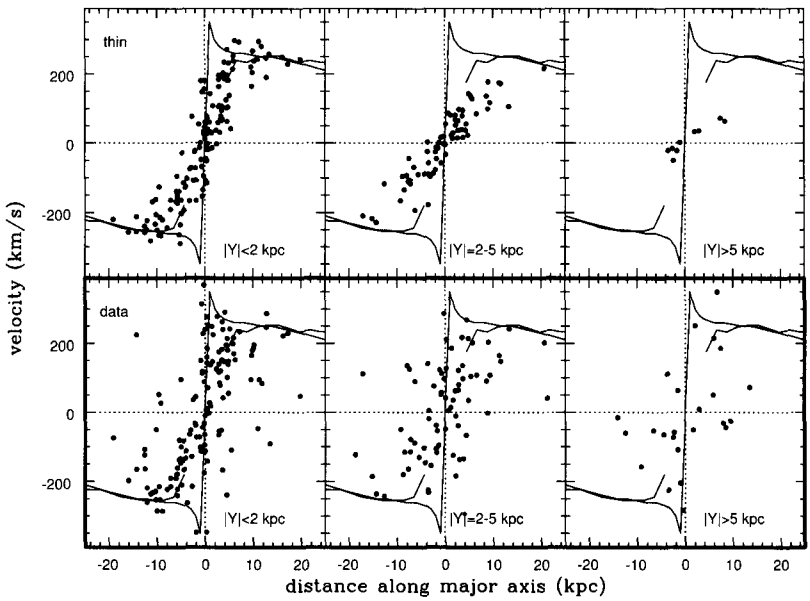

Figure 1. Velocity of globular clusters in M31 with velocity errors less than 20 km/s (lower panels), compared to a realistic thin disk model (upper panels), against major axis distance X. Data are split by distance Y from the major axis. A significant number of objects, particularly those close to the major axis, have thin disk kinematics.

Particularly for clusters within 2 kpc of the major axis, we see a subsystem with disk kinematics as well as a group with hotter kinematics. We find that 40% of the clusters projected on M31's disk belong to the disk subsystem. Disk clusters are found over the entire radial range of the M31 stellar disk. Studies of the age of these clusters will constrain the epoch of disk formation in M31, but it seems likely from existing work that they are old, suggesting that M31 had a large thin disk in place quite early.

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