LECTURE 17:
ANDROMEDA AND THE MILKY WAY
II. STELLAR POPULATIONS

## 17.1 ANDROMEDA AND THE MILKY WAY

Andromeda and the Milky Way are both galaxies, of similar type.

Milky Way: we see details, but we lack perspective because
(a) we're stuck in the disk
(b) dust obscures our view.

Andromeda: we see it whole, but only the brightest stars can be resolved individually.

We can build a more complete picture by examining both galaxies and comparing them.

Milky Way $\longrightarrow$ shows us the trees
Andromeda $\longrightarrow$ shows us the forest

## 17.2 A COMMENT ON STELLAR AGES

The relevant timescale for distinguishing between "young" and "old" stars is the age of the universe, roughly 10 billion years.

Massive stars run out of fuel quickly, so:
A high-mass main sequence star (blue, high luminosity) *must* be young.
A low-mass main sequence star (red, low luminosity) can be old or young.

A star cluster with blue main sequence stars is young.

A star cluster without blue main sequence stars is old.

## 17.3 THE DISCOVERY OF STELLAR POPULATIONS

Photographs of Andromeda show:
a *disk*: extended, flat, with wispy spiral structure
a *spheroid*: centrally concentrated, thick
[Note: a spheroid is the shape of a squashed sphere. In Seeds' terminology, the spheroid is the "spherical component," consisting of a *nuclear bulge* and a *stellar halo*.]
In color images, the spheroid looks red, the disk blue.

Walter Baade, in 1944, took deep blue and red photographs of Andromeda.
He resolved many individual stars and plotted them on HR diagrams. He found that:

Andromeda's disk stars have an HR diagram similar to that of stars near the sun.

Andromeda's spheroid stars have an HR diagram similar to that of globular clusters.

Baade called the disk stars *Population I* and the spheroid stars *Population II*. These two populations also exist in the Milky Way.

### 17.4 POPULATION I

The two stellar populations differ from each other in spatial distribution, age, and composition.

Features of Population I:

- occurs in disk
- old and young stars
- open clusters (and isolated/binary stars)
- roughly solar metallicity
  [typical composition 70% hydrogen, 28% helium, 2% metals]

Associated with Population I:

- interstellar gas and dust
- star-forming gas clouds
- Type II supernovae

### 17.5 POPULATION II

Features of Population II:

- occurs in spheroid, especially the stellar halo
- old stars only (no blue main sequence stars)
- globular clusters (and isolated/binary stars)
- low metallicity, 1/1000 to 1/100 solar
  [typical composition 75% hydrogen, 24.99% helium, 0.01% metals]

Associated with Population II:

- very little interstellar gas or dust
- no star formation
- only Type I supernovae

### 17.6 A CLUE TO GALAXY FORMATION?

Heavy elements (metals) form in stars and are ejected by supernova explosions.

A plausible picture:

Spheroid stars formed first.
High mass stars exploded as supernovae, produced metals, and are now gone (except for their remnant neutron stars and black holes).
Low mass stars are still around today.

The remaining gas, enriched with metals, settled into a disk.
Population I stars formed from this gas.
Some star formation is still going on in the disk.

## 17.7 ORBITS OF STARS

A galaxy is held together by gravity.

Stars don't fall to the middle because they orbit, like planets around the sun.

In the spheroid, stars are on disordered, elliptical orbits. Nearby stars may be moving in different directions and at different speeds. Stellar collisions are extremely rare because the spaces between stars are enormously larger than the stars themselves.

In the disk, all stars are on ordered, nearly circular orbits. Nearby stars are moving at similar speeds in the same direction.

## 17.8 SUMMARY

The Milky Way and Andromeda provide us with complementary information — "inside" and "outside" views of a galaxy.

Each galaxy has a spheroid of *Population II* stars and a disk of gas and *Population I* stars.

Population I: young and old, solar metallicity, open clusters, ongoing star formation.

Population II: old, low metallicity, globular clusters, no ongoing star formation.

A plausible history: spheroid stars formed first, disk stars formed from metal-enriched gas.

Spheroid: orbits are elliptical, disordered.
Disk: orbits are nearly circular, ordered.