

Age Dating Clusters in the Antennae Galaxies



Background:

One of the important early results from the *Hubble Space Telescope* was the existence of actively merging galaxies. One of the nearest and most impressive examples is the Antennae Galaxies (NGC 4038/NGC 4039). The visible results of these two galaxies' merger include long tidal tails and "super star clusters." The feature we are most interested in here is the latter; super star clusters pumping out stars and young globular clusters.

Cluster age can be evaluated using single stellar population models (SSPs). An SSP differs from an isochrone in that it does not assume that all the objects formed at the same time. Plotting an SSP on a color-color diagram, say V-I vs U-B, is particularly illuminating, as it shows that as clusters age and their stars turn off the main sequence they get progressively redder.

Age-dating clusters is complicated by two things; differentiating the clusters from the surrounding stars and accounting for extinction.

A cluster can be distinguished from a star in two ways: absolute magnitude and concentration index. The idea behind the former is simple – clusters contain millions of stars that all contribute light, so their absolute magnitude is inherently greater than a star. In the case of Antennae observations, a decent rule of thumb is that sources with $M_v < -9$ are clusters. The concentration index (CI) is the difference between magnitudes measured in a two different apertures, for example one with a radius of 1 pixel and a second with a radius of 6 pixels. This method distinguishes between stars and clusters because clusters are really not point sources, so they generally have larger CIs.

Evaluating interstellar extinction is a more qualitative process than distinguishing clusters. Using the extinction in each filter, one can compute the slope of the “reddening vector.” Clusters in the color-color diagram are pushed redder, in the direction of this vector. Thus, clusters may appear older on the diagram than they truly are.

Despite these difficulties, color-color diagrams and SSPs can give a rough estimate of the cluster ages.

Purpose:

Construct a color-color diagram of the Antennae, complete with SSP, clusters and reddening vector. Use this diagram to take a stab at *qualitatively* age dating some of the clusters. (Pull out an age group and see at what those clusters really look like. Are all the oldest clusters bright purple? Clearly they’re not, but you should be able to make at least one qualitative statement.)

Things you will need to get:

DAOphot catalogs for HST project ID 05962, visit 4 (Hubble Legacy Archive)

SSP cluster evolution model (Padova’s CMD database has sets. Make sure to pick the right filters.)

Extinction for each band (NED has UBVRI extinction, don’t worry about the different magnitude system)

Distance modulus of the Antennae (see Whitmore et al. 2010)

Hints:

WFPC2 Zeropoints

Filter	VEGAMAG	ABMAG
F300W	19.43571	20.76789
F336W	19.44119	20.61961
F439W	20.93019	20.77772
F450W	22.02992	21.93849
F555W	22.57747	22.57336
F606W	22.91335	23.01226
F814W	21.68402	22.10077