Defining the Spatial Extent of the Virgo Overdensity and the Sagittarius Dwarf Tidal Stream with MilkyWay@home

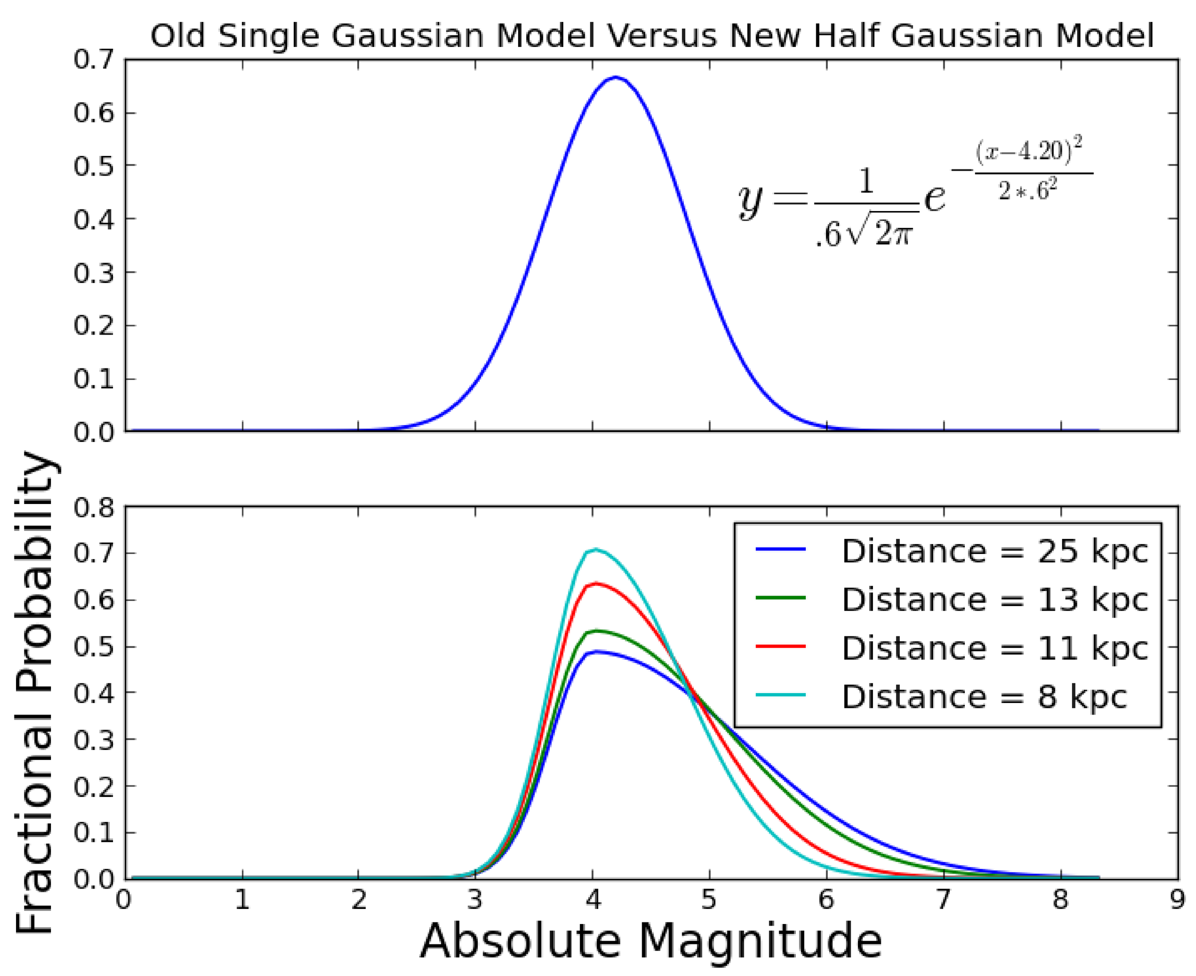
Jake Weiss[1], M. Arsenault[1], T. Bechtel[2], T. Desell[3], H. Newberg[1], M. Newby[1], J. Thompson[1]

[1]Rensselaer Polytechnic Institute, [2] University of Wisconsin-Madison, [3] University of North Dakota

Abstract:

We refine and present tests of the statistical photometric parallax methods used to measure substructure of the halo stars with MilkyWay@home. This newer algorithm is showing promise for separating three substructure components, including the two parts of the bifurcated Sagittarius tidal stream and the Virgo Overdensity. We show that the Sagittarius tidal streams and the Virgo Overdensity are much wider than previously imagined. We present the new results in the context of previous measurements of the properties of these halo substructures. This research was funded by NSF grant AST 10-09670, the Rensselaer Center for Open Source Software (RCOS), and crowd funding from the MilkyWay@home volunteers.

Main Sequence Turn-Off (MSTO) Star Distribution:

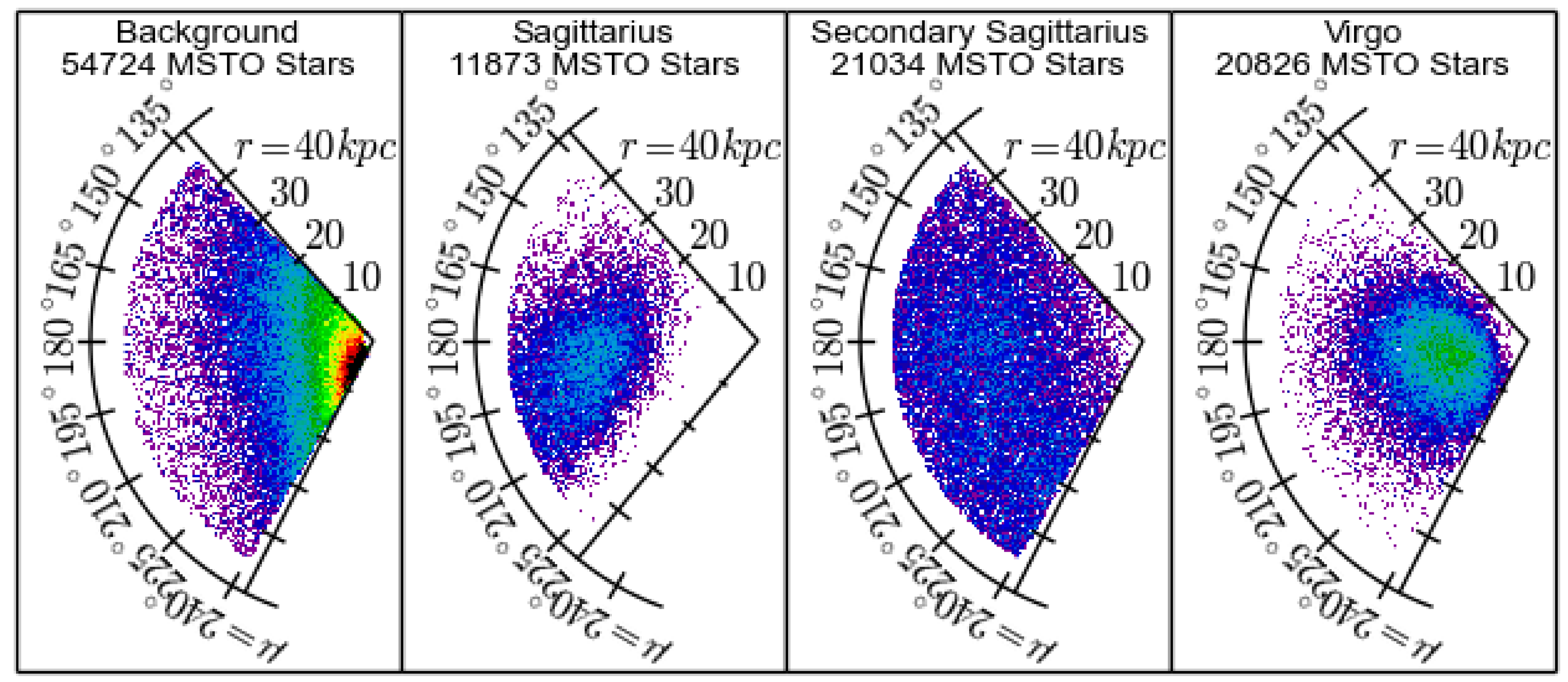


Originally, the absolute magnitude distribution of MSTO stars was simplified in Newberg & Yanny 2006 to follow a Gaussian profile with a mean magnitude of 4.20 and a standard deviation of .6 as is shown in the figure above. Newby et al. 2011 revisited this model and made some minor adjustments to the distribution now modeling the distribution with two half Gaussian profiles where the left has a standard deviation of .36 and the right has a standard deviation that follows the function:

$$\sigma_r = \frac{\alpha}{1 + e^{-(d_{eff} - \beta)}} + \gamma$$

where α = 0.52, β = 12.0, and γ = 0.76. The standard deviation increases with distance on the right hand side because redder stars leak into MSTO selection bin as photometric errors increase.

Results For Sloan Digital Sky Survey Stripe 15:



Sagittarius

Source	# of Stars	Mu	R (kpc)	Theta	Phi	Width
New	11,873	189.2	33.8	2.1	3.1	4.4
Newby PhD Thesis	12,519	180±10	27±8	1.9±.7	3.0±.6	3.0±2
Cole PhD Thesis	16,502	184.6±.6	31.2±.5	1.86±.06	3.2±.1	3.2±.8
Newberg et al. 2007	N/A	186	34	N/A	N/A	N/A

Secondary Stream

Source	# of Stars	Mu	R (kpc)	Theta	Phi	Width
New	21,034	211.5	35.6	1.4	3.2	19.9

Virgo

Source	# of Stars	Mu	R (kpc)	Theta	Phi	Width
New	20,826	190.9	14.7	1.9	-0.1	3.9
Carlin et al. 2012	N/A	N/A	14±3	N/A	N/A	N/A
Newberg et al. 2007	N/A	N/A	~18	N/A	N/A	N/A

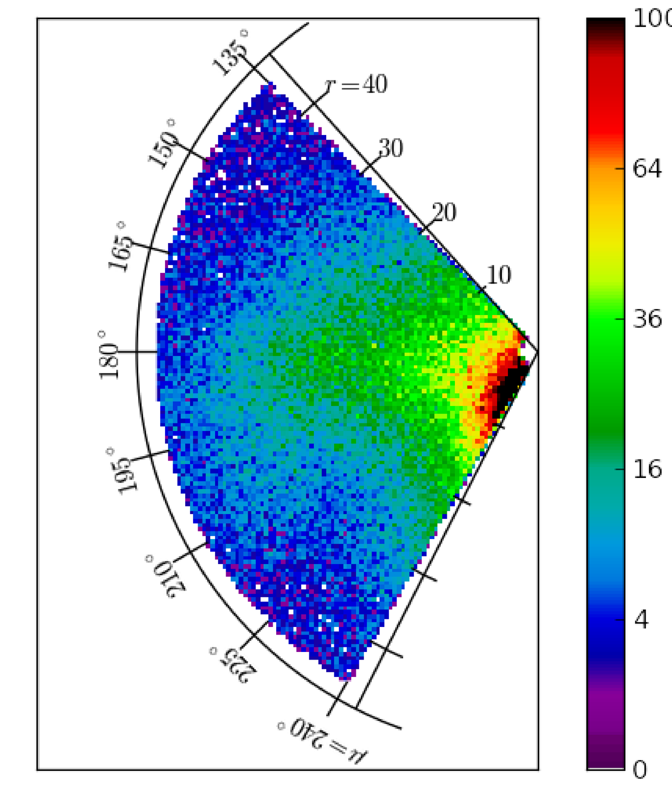
Notes:
Newberg at al. 2007 data was a few degrees away from stripe 15 in Dec.

References:

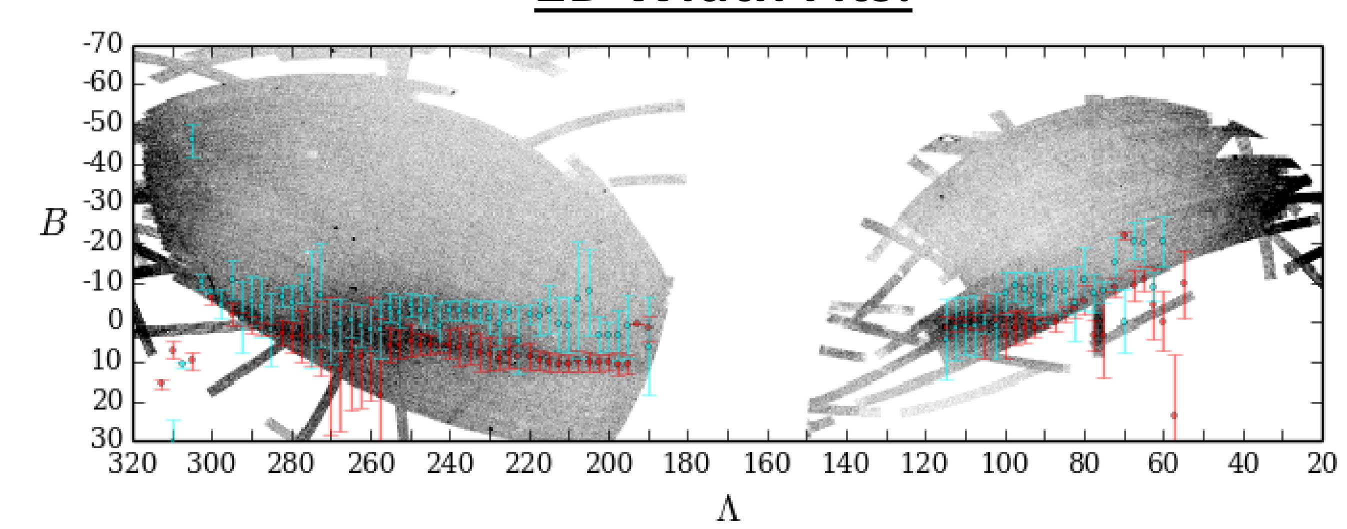
- Abazajian et al.2009
- Carlin et al. 2012
- Cole et al. 2008
- Cole PhD. Thesis
- Newberg and Yanny 2006
- Newby et al. 2011
- Newby et al. 2013
- Newby PhD. Thesis
- Newby AAS Talk #119.04 Meeting #225

Results For Sloan Digital Sky Survey Stripe 15:

Stripe 15 All MSTOs



2D Width Fits:



This is a plot of all of the MSTO stars in the Sloan Digital Sky Survey with 16.5 < g_o< 22.5. The data was divided in lambda and then binned in beta. For each lambda histogram, the centers and widths of two Gaussians and a line were fit to the data. The widths of the fit Gaussians are overlaid on the data showing the width of the streams the fit. In some areas, both Sagittarius and its secondary stream are fit. Meanwhile, there are other areas where it prefers to fit Virgo and Sagittarius.

Conclusions:

The new fits to Sagittarius look promising. The farther distance of Sagittarius is more consistent with other sources than previous results with MilkyWay@home. The width of the secondary stream is still unreasonably large. This leads to a couple possibilities:

- Our background model is inaccurate and the leftover stars are being put into this stream.
- The stream is completely disrupted.
- The stream does not fit our stream model.

With the new model for MSTO absolute magnitude distribution, we are now consistently finding Virgo in our data. The distance we are finding to Virgo is consistent with previous results, but more work must be done to confirm the other parameters are realistic.