Using A New Model for Main Sequence Turnoff Absolute Magnitudes to Measure Stellar Streams in the Milky Way Halo

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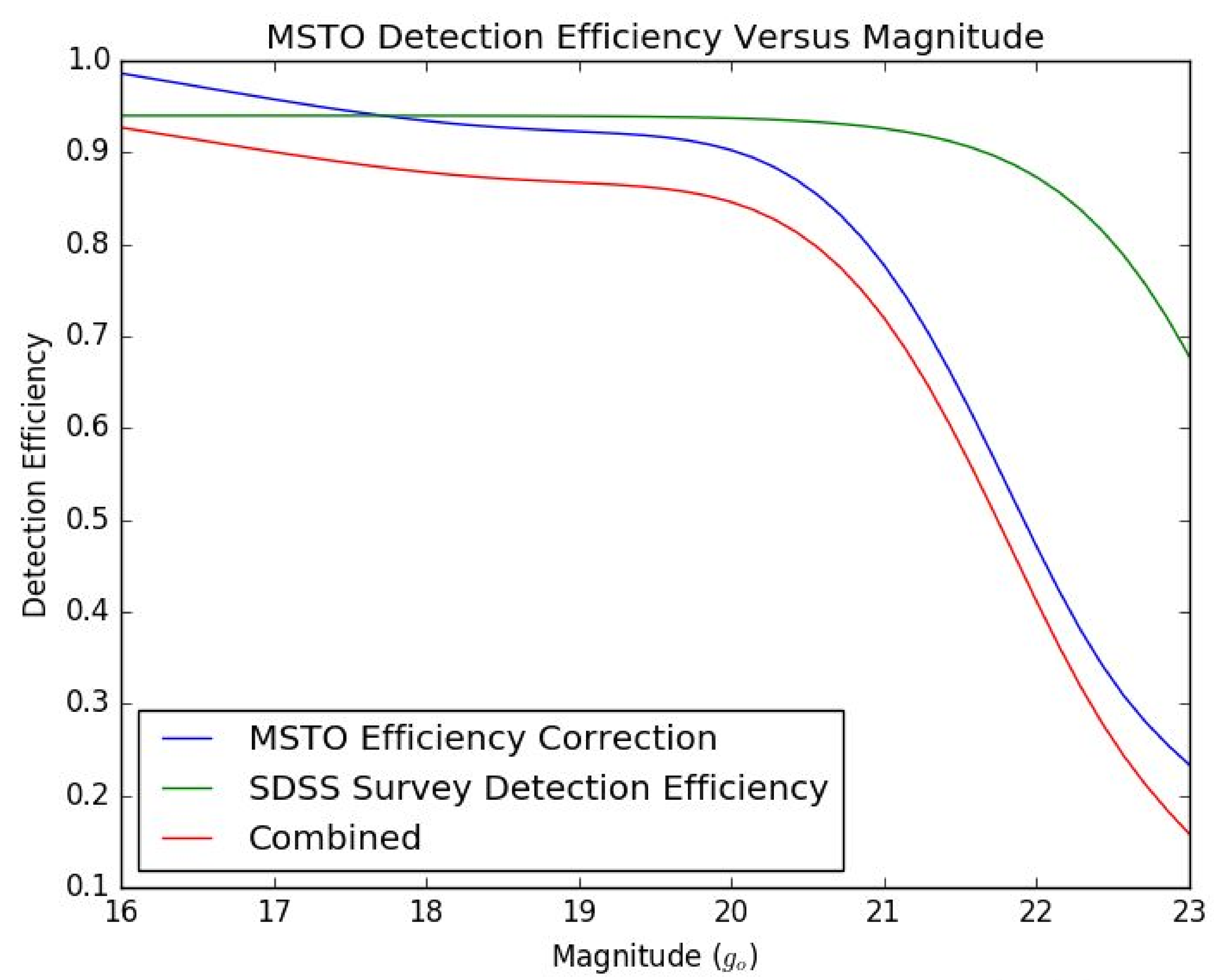
Abstract:

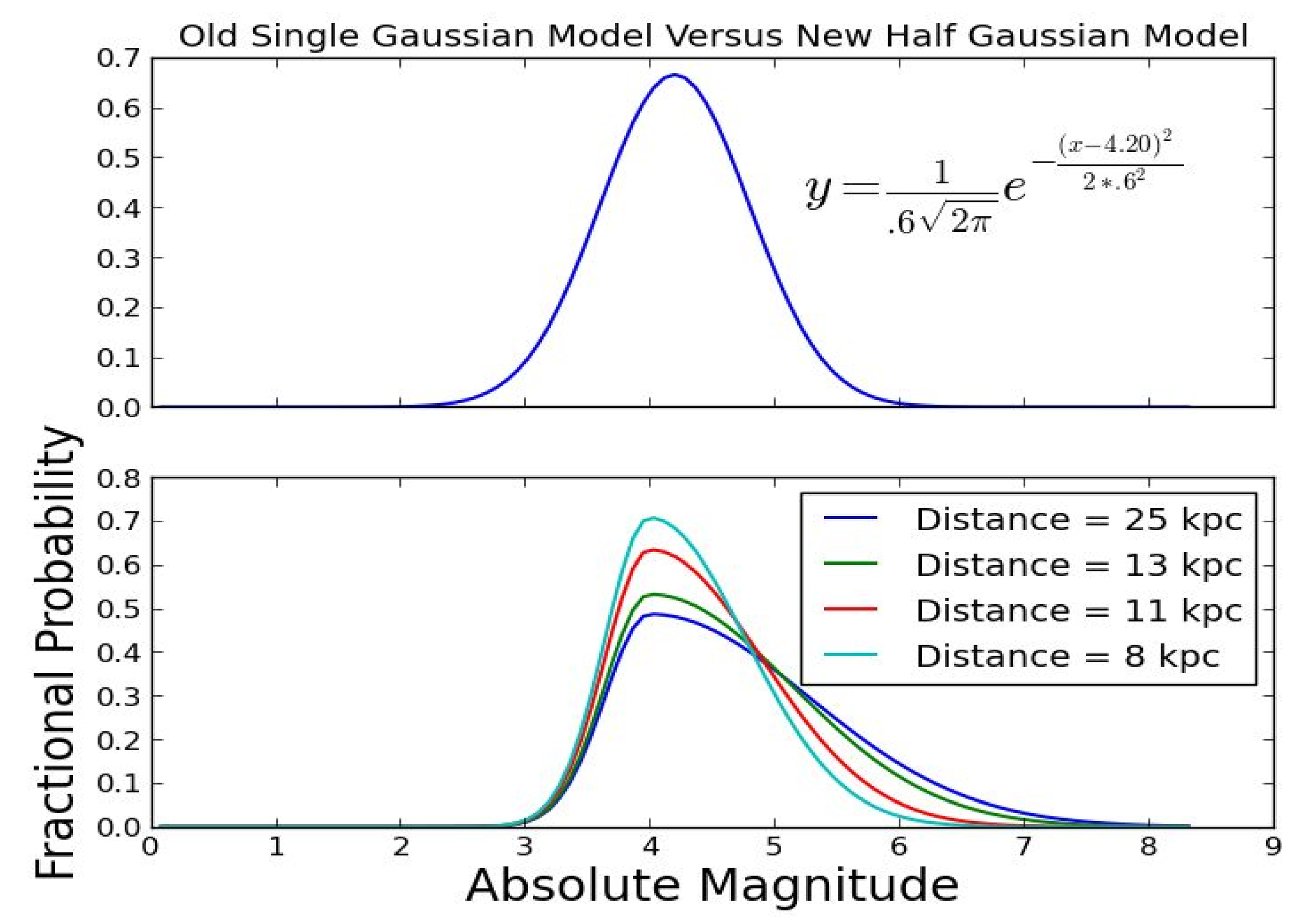
Statistical photometric parallax is a method for using the distribution of absolute magnitudes of stellar tracers to statistically recover the underlying density distribution of these tracers. In previous work, statistical photometric parallax was used to trace the Sagittarius Dwarf tidal stream, the so-called bifurcated piece of the Sagittaritus stream, and the Virgo Overdensity through the Milky Way. We use an improved knowledge of this distribution in a new algorithm that accounts for the changes in the stellar population of color-selected stars near the photometric limit of the Sloan Digital Sky Survey (SDSS). Although we select bluer main sequence turnoff stars (MSTO) as tracers, large color errors near the survey limit cause many stars to be scattered out of our selection box and many fainter, redder stars to be scattered into our selection box. We show that we are able to recover parameters for analogues of these streams in simulated data using a maximum likelihood optimization on MilkyWay@home. We also present the preliminary results of fitting the density distribution of major Milky Way tidal streams in SDSS data. This research is supported by generous gifts from the Marvin Clan, Babette Josephs, Manit Limlamai, and the MilkyWay@home volunteers.

MSTO Detection Efficiency Correction:



In the original work done by Newby et al. 2013, the SDSS detection efficiency was accounted for, but the effects of stars shifting into and out of the MSTO color selection criteria, due to increasing color error with distance, was not accounted for. In our new model we account for this effect and a new total detection efficiency is calculated by multiplying the two detection efficiencies together.

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 = 0.52, = 12.0, and = 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.

Conclusions:

While we are currently having trouble calculating uncertainty values for our results, at first glance it seems we are capable of recovering all 18 parameters needed to characterize the three streams present in our data. This is possible on both a model exactly representative of that which we are fitting and a model in which we are trying to fit an incorrect background. The background model we typically attempt to fit to SDSS data follows a Hernquist density profile, while in the different background section, we generated the simulated data with a broken power law background (Ahkter et al. 2012) and fit it with a Hernquist background. Even with an incorrect background, our ability to characterize streams is minimally affected. The final piece of this research will be to calculate the errors for our fits and then recompare the results to their expected values.

Results For Simulated Data:

Sagittarius

Source	# of Stars	Mu	R (kpc)	Theta	Phi	Width
Simulated	12,073	190	33.9	1.85	3.05	4.5
MilkyWay@home Result	14,904	190	34.4	1.72	3.08	4.8
MilkyWay@home Different Background	12,838	190	34.3	1.79	3.12	4.0

Secondary Stream

Source	# of Stars	Mu	R (kpc)	Theta	Phi	Width
Simulated	20,926	210	35.5	1.50	3.18	10
MilkyWay@home Result	21,150	217	35.5	1.62	3.13	11.7
MilkyWay@home Different Background	18,401	214	34.1	1.12	2.81	14

Virgo

Source	# of Stars	Mu	R (kpc)	Theta	Phi	Width
Simulated	21,349	180	14.6	1.97	-0.40	4.2
MilkyWay@home Result	19,330	179	15.1	1.91	-0.24	3.7
MilkyWay@home Different Background	24,105	178	15.2	1.68	-0.33	4.1

References:

- Abazajian et al. 2009
- Ahkter et al. 2012
- 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

Acknowledgments:

Funding from the Marvin Clan, Babette Josephs, Manit Limlamai, and the 2015 Crowd Funding Campaign to Support Milky Way Research.

Also thank the MilkyWay@home volunteers