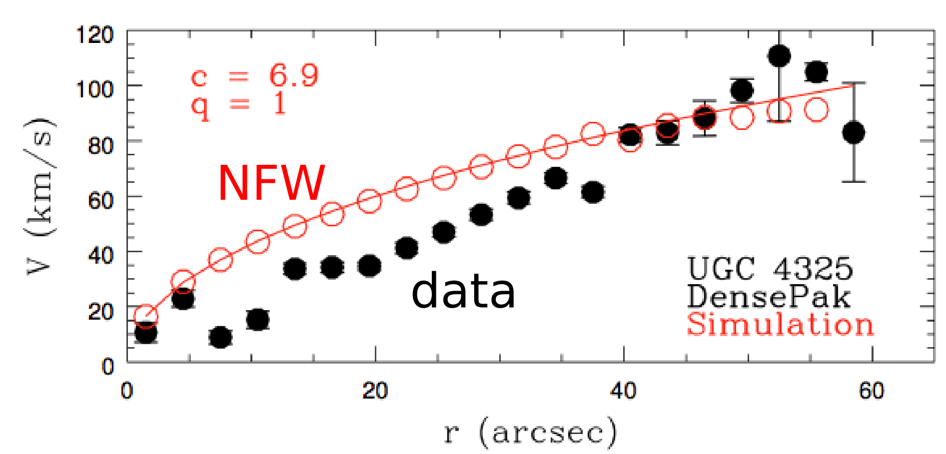
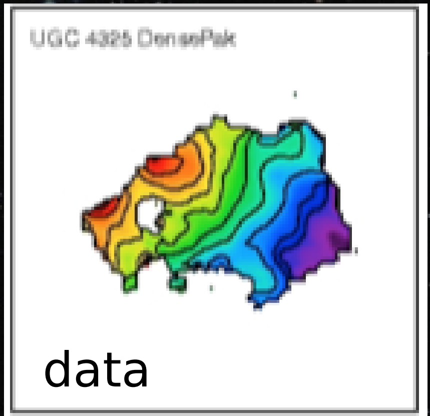
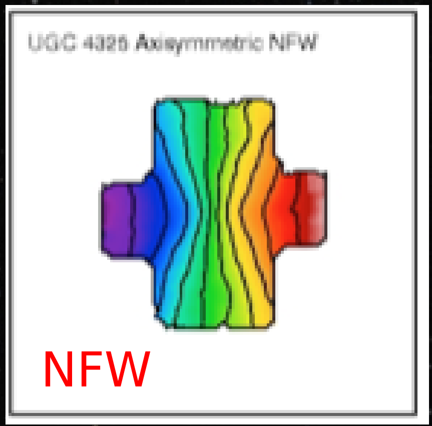
Outstanding Questions for the Local Volume

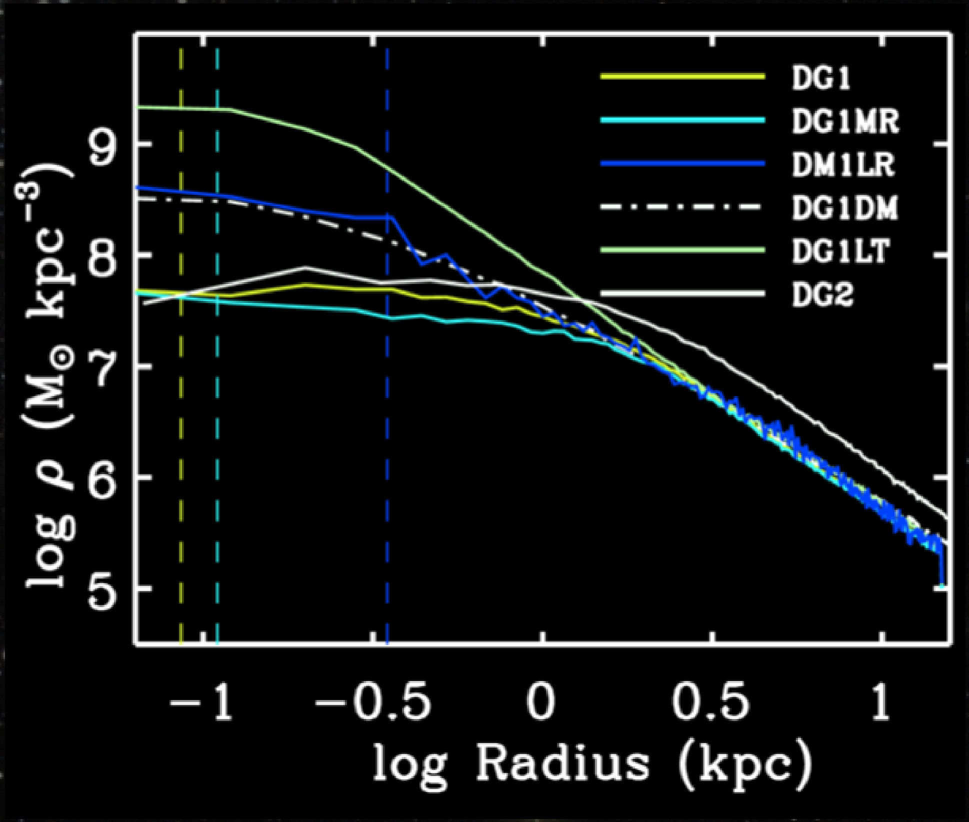
What is the Local Volume telling us about *dark matter*?



cusps would be easily detected if present







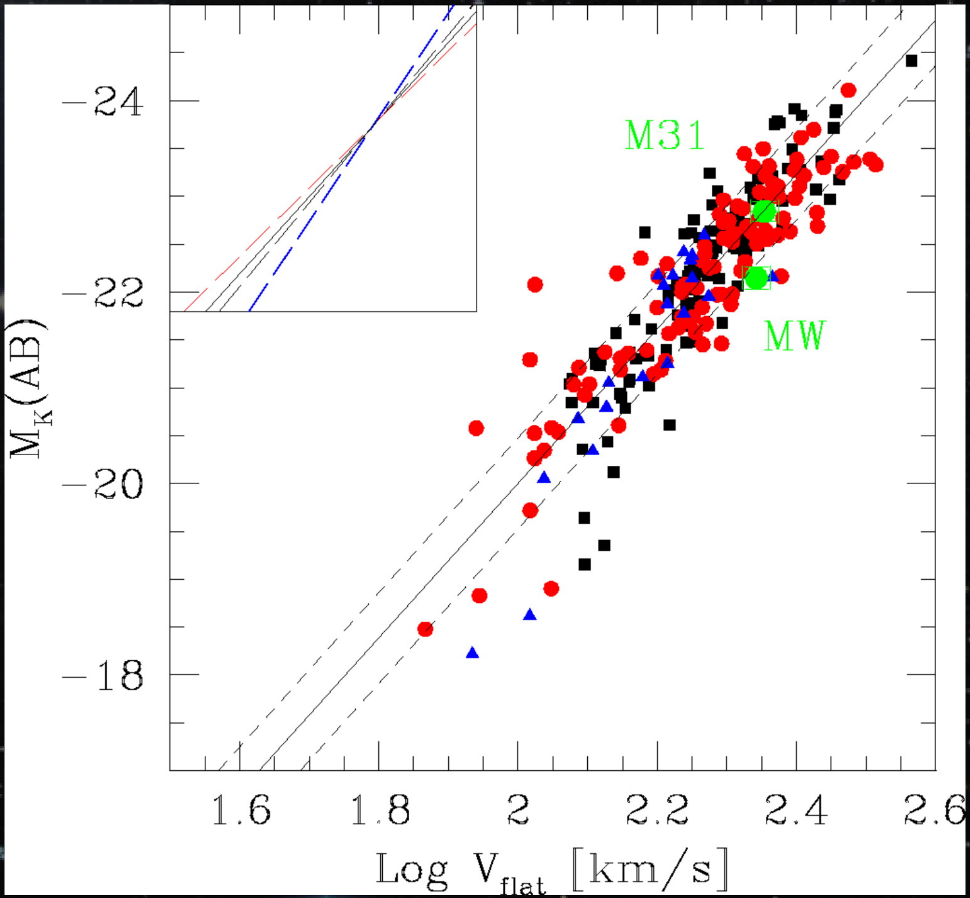
Governato et al. 2010, 463, 203

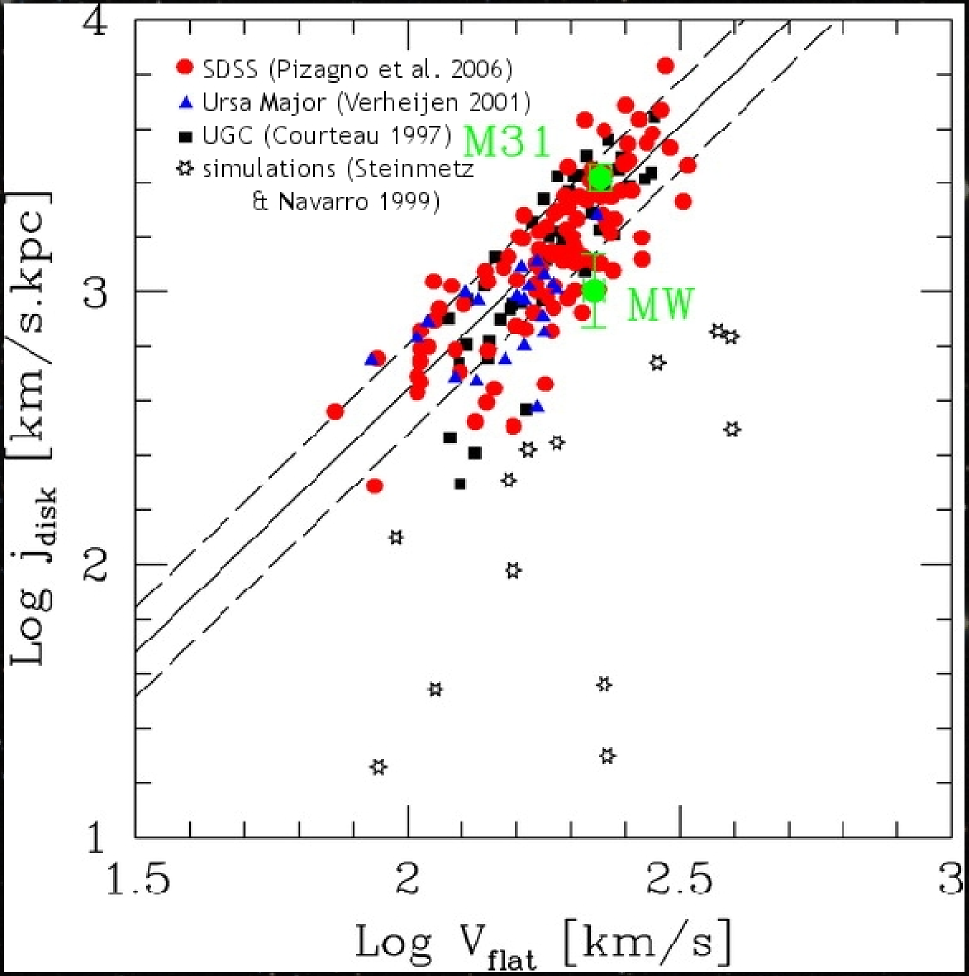
Kuzio de Naray et al. 2010, ApJL, 710, L161

Kuzio de Naray & Kaufmann 2010, MNRAS, submitted, arXiv:1012.3471

What is the Local Volume telling us about *dark matter*?

How representative is the Milky Way of a typical disk galaxy?





Hammer et al. 2007, ApJ, 662, 322

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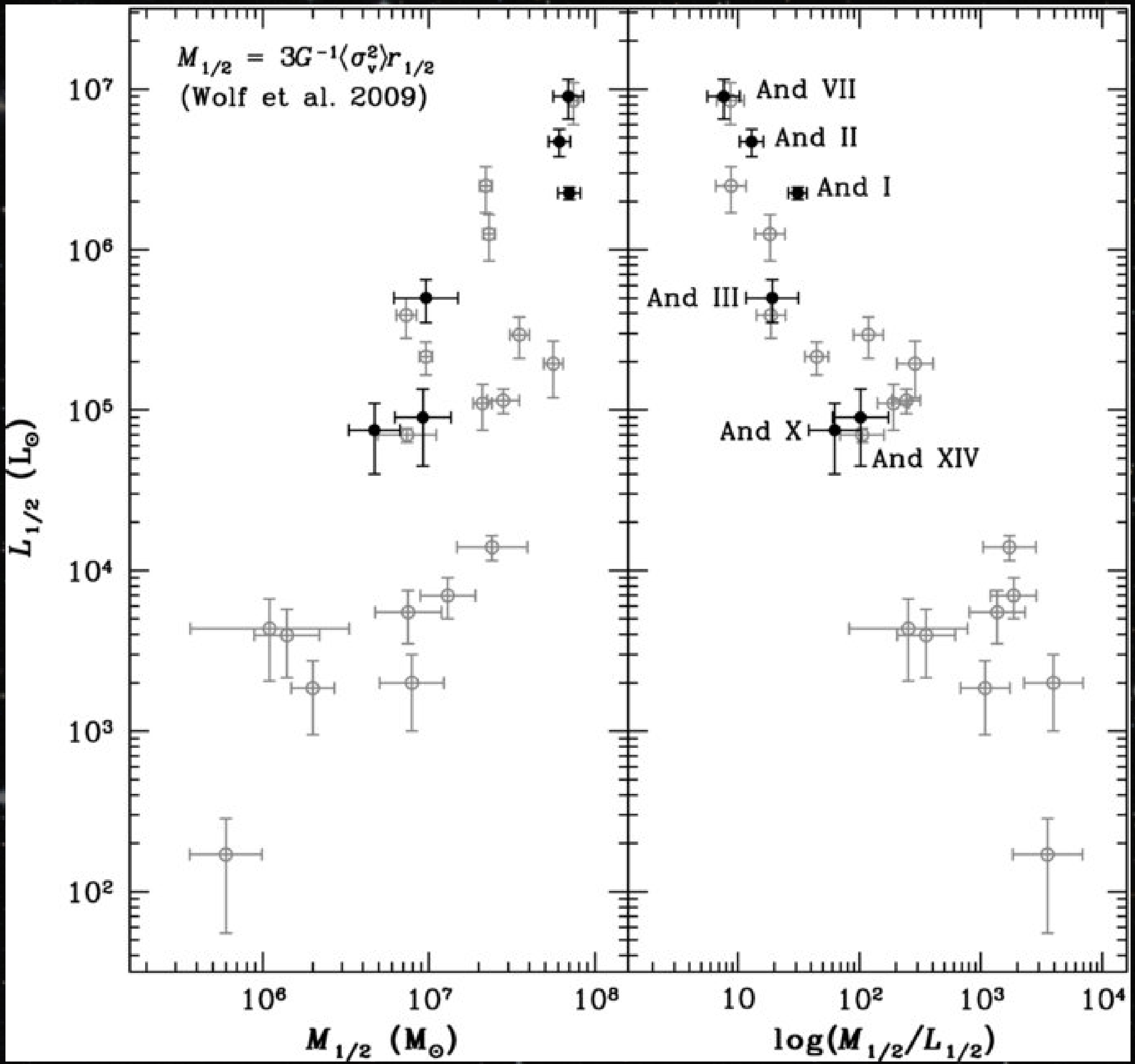
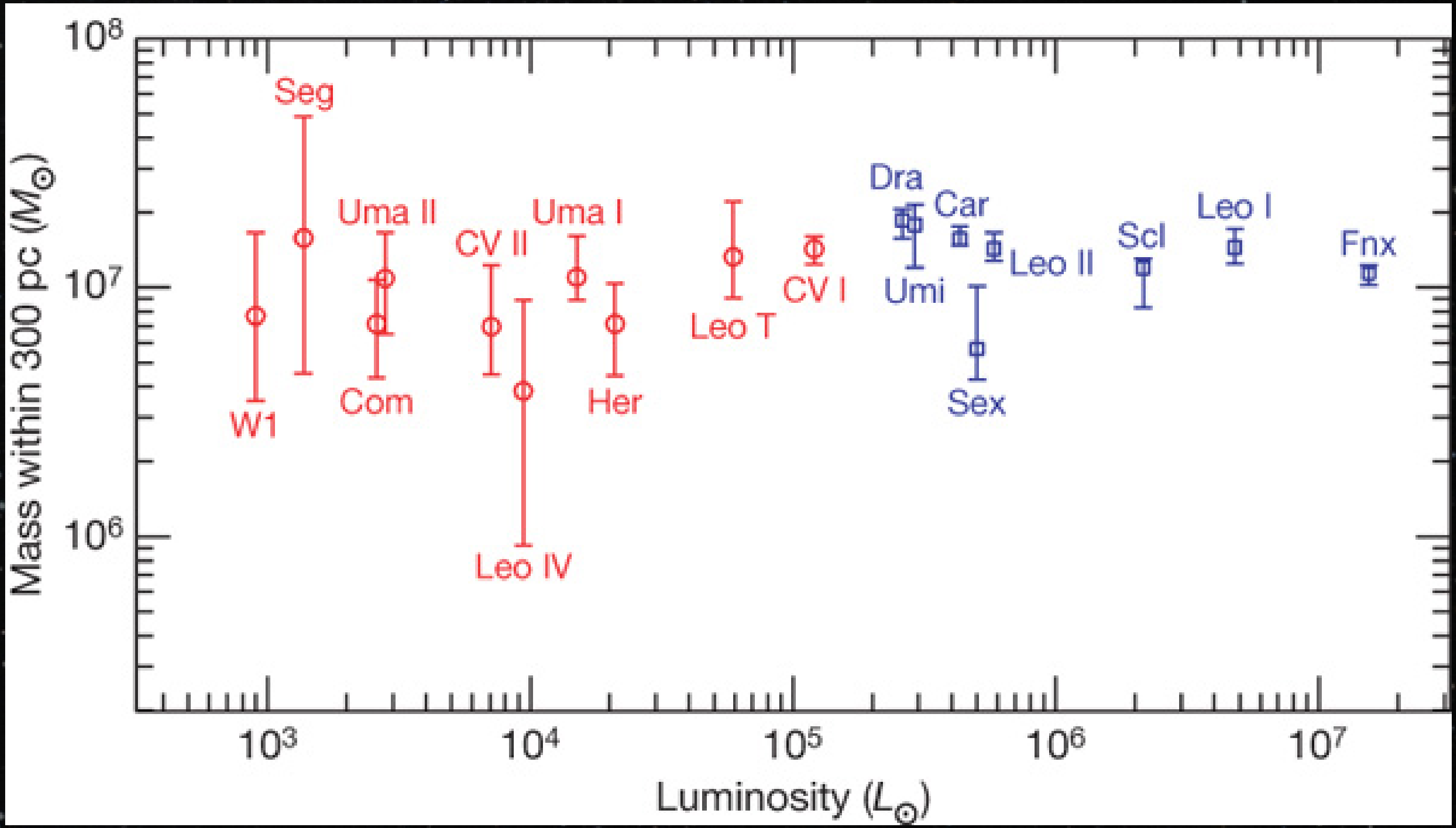


Kalirai et al. 2010, ApJ, 711, 671
also see McConnachie & Irwin 2006, MNRAS, 365, 1263

What are the Milky Way satellites telling us about *galaxy formation*?



Strigari et al. 2008, Nature, 454, 1096

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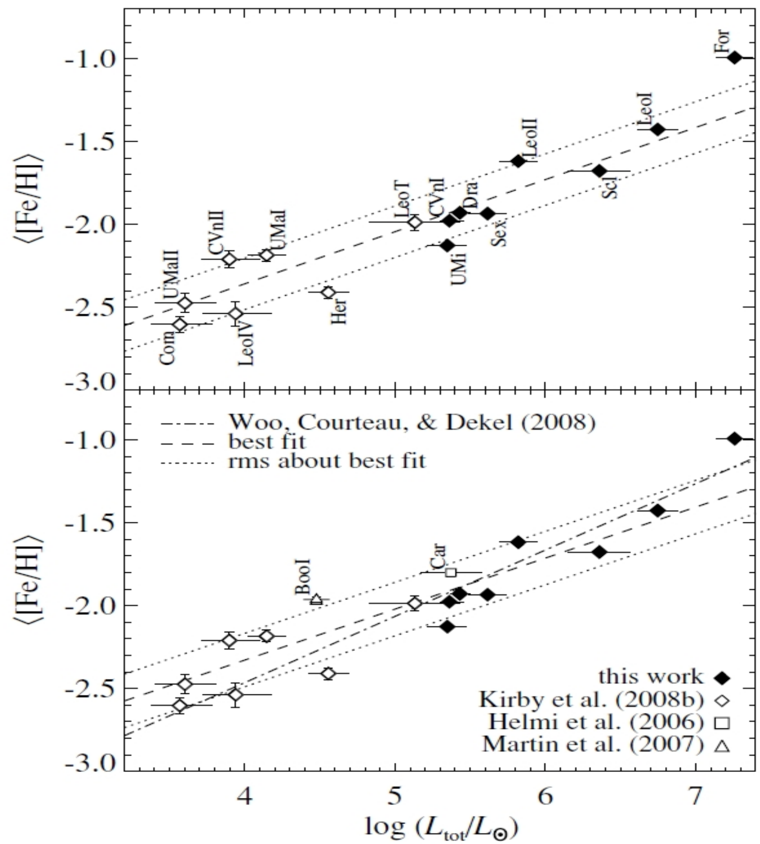

Figure 3. Top: the mean [Fe/H] of MW dSphs as a function of total luminosity. The dashed line is the weighted, orthogonal regression linear fit in log(L)–[Fe/H] space, accounting for the errors in both L and [Fe/H] (Akritas & Bershady 1996). The dotted lines are the rms dispersion of the residuals. The filled diamonds represent measurements from this series of papers. The open diamonds represent the updated measurements of Kirby et al. (2008b), which were performed identically to those measurements presented here. Bottom: same as the top panel, with two more galaxies that were not measured in the same way. Metallicity measurements for Boötes I and Carina are based on the equivalent width of the Ca triplet. The dot-dashed line is the relation of Woo et al. (2008) from Local Group galaxies, including galaxies much more luminous than Fornax.

Kirby et al. 2011, ApJ, 727. 78

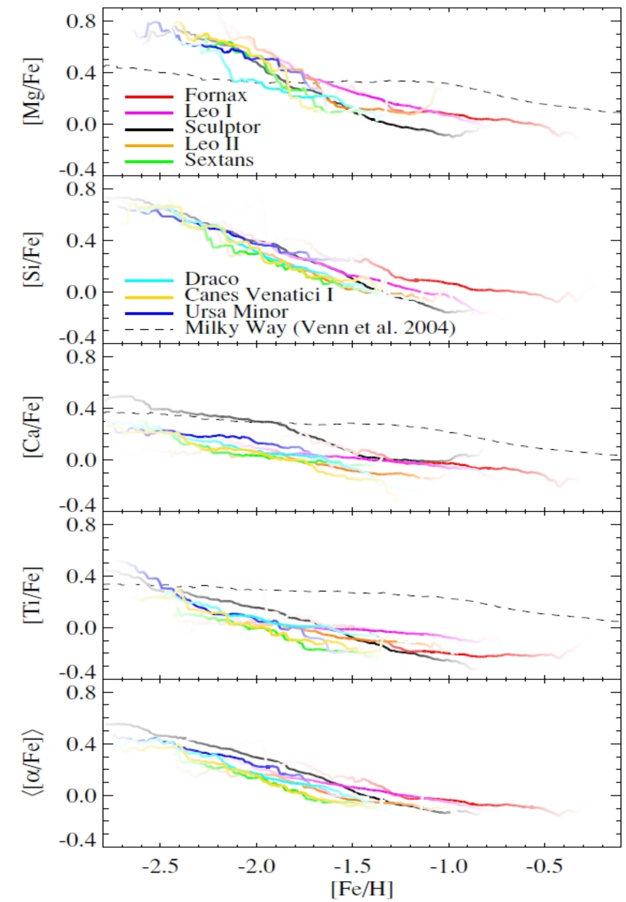

Figure 13. Moving averages, inversely weighted by measurement uncertainty, of abundance ratios for the eight dSphs and for the MW (Venn et al. 2004, who compiled data from the references given in footnote 6). The bottom panel shows ⟨[α/Fe]⟩, the average of the top four panels. The line weight is proportional to the number of stars contributing to the average. The legend lists the dSphs in decreasing order of luminosity. Except for [Ca/Fe] in Sculptor, the abundance ratios do not show a low-metallicity plateau, which indicates that Type Ia SNe explode for nearly the entire duration of star formation. Our data are sparse at [Fe/H] < -2.5, and Type Ia SNe need not explode at times corresponding to those low metallicities. Only the galaxies luminous enough to reach [Fe/H] $\gtrsim -1$ eventually achieve an equilibrium between Types II and Ia SNe and therefore a plateau at high metallicity.

Kirby et al. 2011, ApJ, 727. 79

What are the Milky Way satellites telling us about *galaxy formation*?

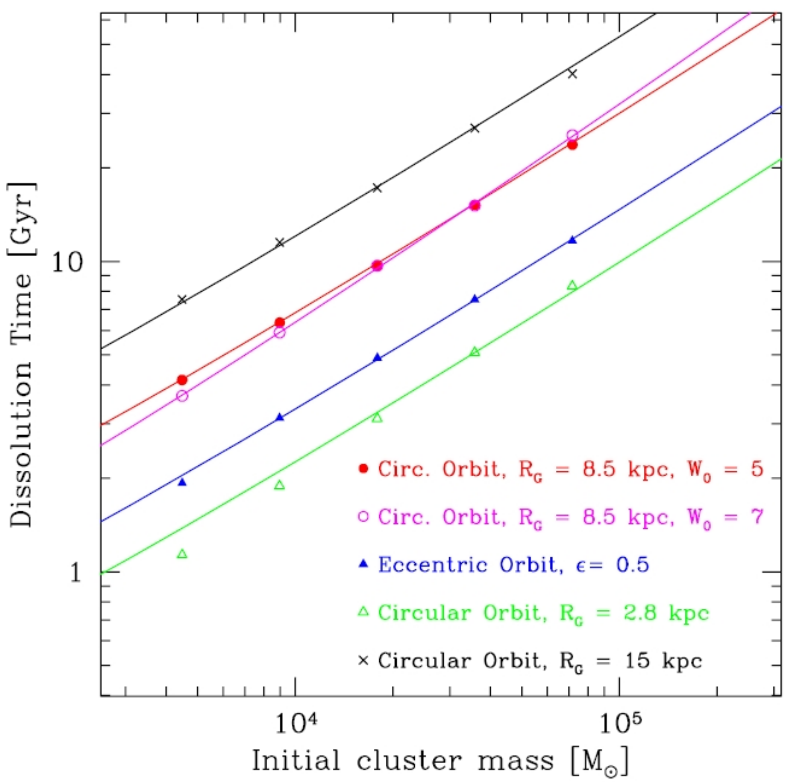

Fig. 3. Lifetimes of star clusters in dependence of their mass for clusters moving in different orbits and starting from different initial King models. In all cases, the lifetimes show a scaling with the mass close to $T_{Diss} \sim M^{0.75}$.

Baumgardt 2006, invited review for "Globular Clusters: Guides to Galaxies," astro-ph/0605125

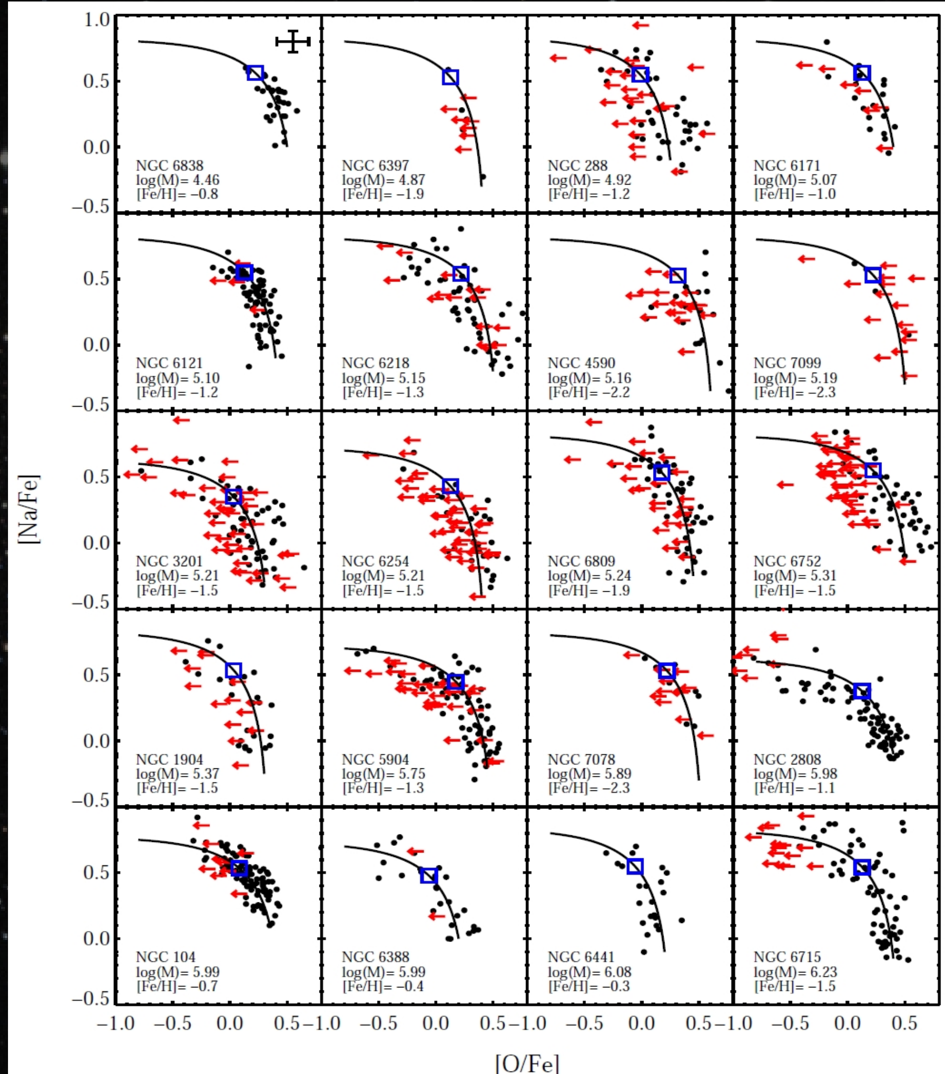

FIG. 3.— Na-O anti-correlation for 20 GCs. Data are from Carretta (2006), Gratton et al. (2007), and Carretta et al. (2007a,c, 2009c,b, 2010d). GCs are sorted by mass, and the logarithm of the GC stellar mass in solar units is shown in each legend, as is the average [Fe/H] of each cluster. Arrows indicate upper limits on [O/Fe] abundances. A typical error on the abundances is shown in the upper left panel. Lines show the dilution models, and open squares mark the location at which the contribution from AGB ejecta and normal material is equal.

Conroy 2011, ApJ, submitted, arXiv:1101.2208

How does *star formation* depend on *environment*?

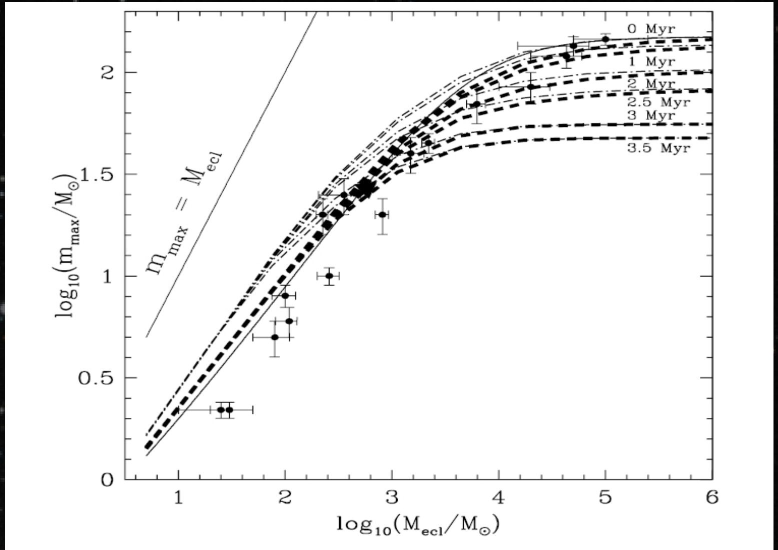

Figure 9. As Fig. 7 but the mean curves include ageing by 1, 2, 2.5, 3 and 3.5 Myr. The stars in the Monte Carlo simulations are subject to stellar evolution according to the SSE package by Hurley et al. (2000) and our own extensions for stars $\geqslant 50\,M_\odot$ which includes not only finite lifetimes but also stellar mass loss. The thick dashed lines are for clusters which are constructed using sorted sampling, while the dot–dashed lines are for constrained sampling. Note that ${}^{l}\overline{m}^{con}_{max}(M_{ecl}) = {}^{l}\overline{m}^{sort}_{max}(M_{ecl})$ for ages $\gtrsim 3$ Myr and $M_{ecl} \geqslant 10^3\,M_\odot$.

Weidner & Kroupa 2006, MNRAS, 365, 1333

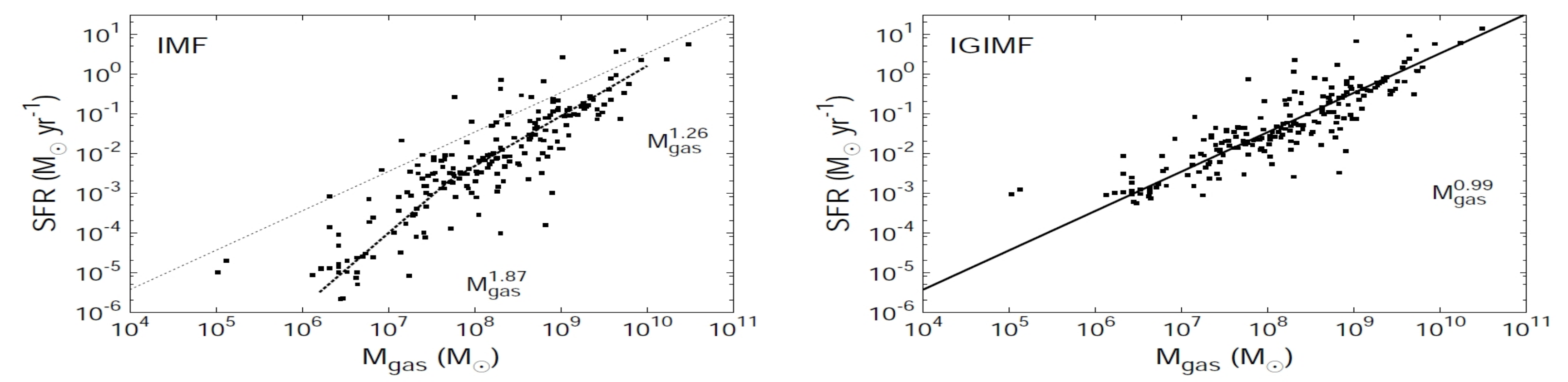

Figure 2. The SFR of galaxies based on Hα luminosities as a function of their total gas mass (from Pflamm-Altenburg & Kroupa 2009). Left: For the case of a constant galaxy-wide IMF. Right: For the IGIMF-theory.

Pflamm-Altenburg, Weidner, & Kroupa 2010, ASP Conf. Ser., arXiv:1011.2200

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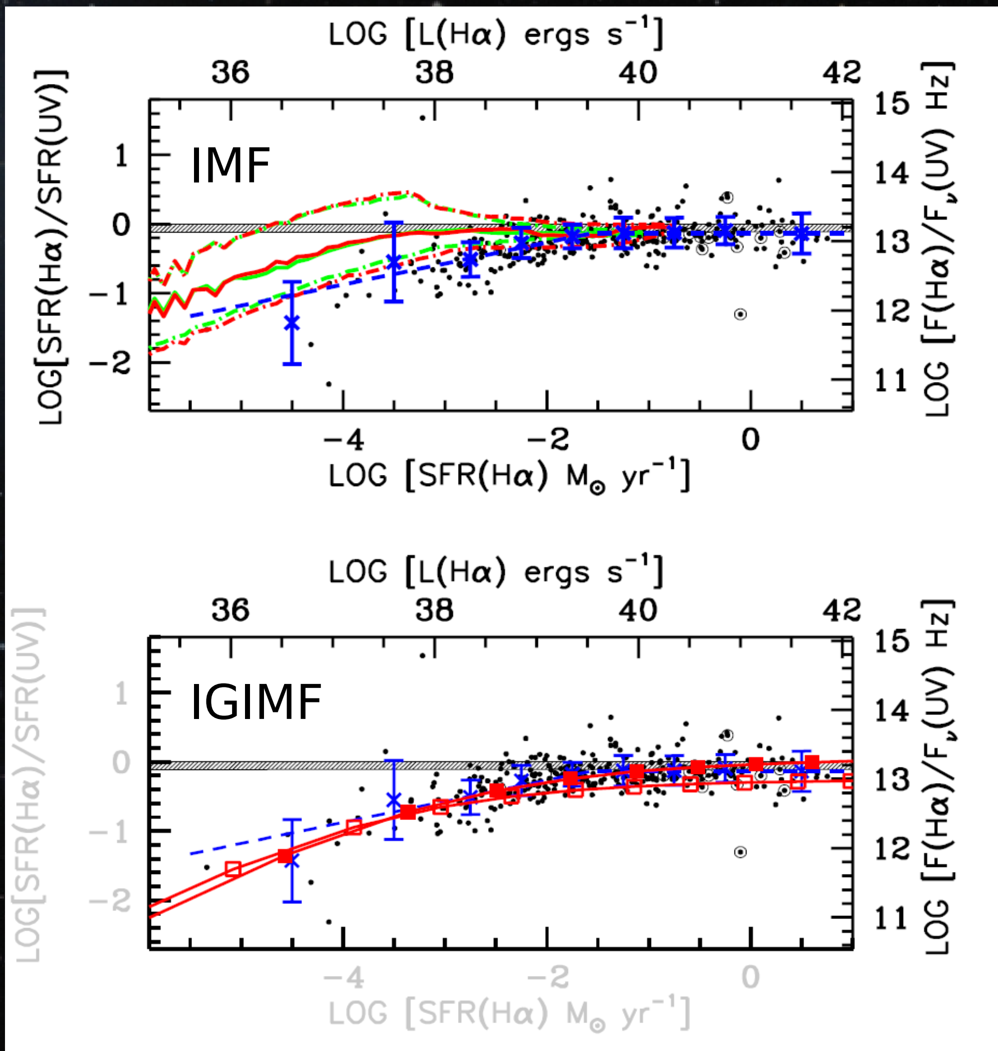
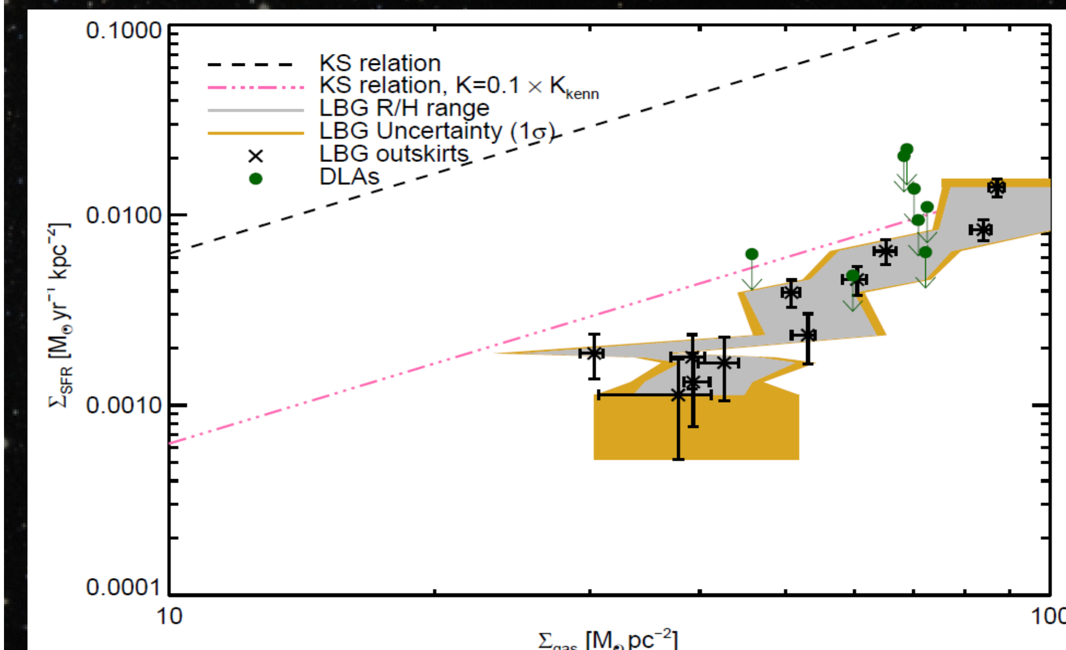


J. C. Lee et al. 2010, arXiv:1011.2181



Rafelski, Wolfe, & Chen 2010, ApJ, submitted, arXiv:1011.6390

- What is the Local Volume telling us about *dark matter*?
- What are Local satellites telling us about *galaxy formation*?
- How does *star formation* depend on *environment*?

What is the Local Volume telling us about *dark matter*?

How representative is the Milky Way of a typical disk galaxy?

PERCENTAGE OF MW-LUMINOSITY HOST GALAXIES WITH N LMC/SMC LUMINOSITY SATELLITES WITHIN A SPHERE OF RADIUS 150KPC, FOR N=0-6

Satellite Counts	Measured % of MW analogs	Systematic Loss Adjustment	Annulus Systematic Uncertainty[a]
Zero	$83.4^{+1.5}_{-1.4}$	-2.0	-4.2
One	$10.8^{+1.8}_{-1.6}$	+0.8	+2.6
Two	$3.1^{+1.3}_{-1.5}$	+0.4	+1.6
Three	$1.4^{+0.9}_{-1.0}$	+0.2	+0.1
Four	$0.7^{+0.6}_{-0.5}$	+0.4	+0.2
Five	$0.1^{+0.2}_{-0.1}$	+0.2	+0.1
Six	$0.1^{+0.2}_{-0.1}$	-0.1	+0.1

[a] This is our estimate for the *maximum* additional correction that might be required to account for having chosen a non-optimal annulus for background estimation.

Liu et al. 2010, ApJ, submitted, arXiv:1011.2255

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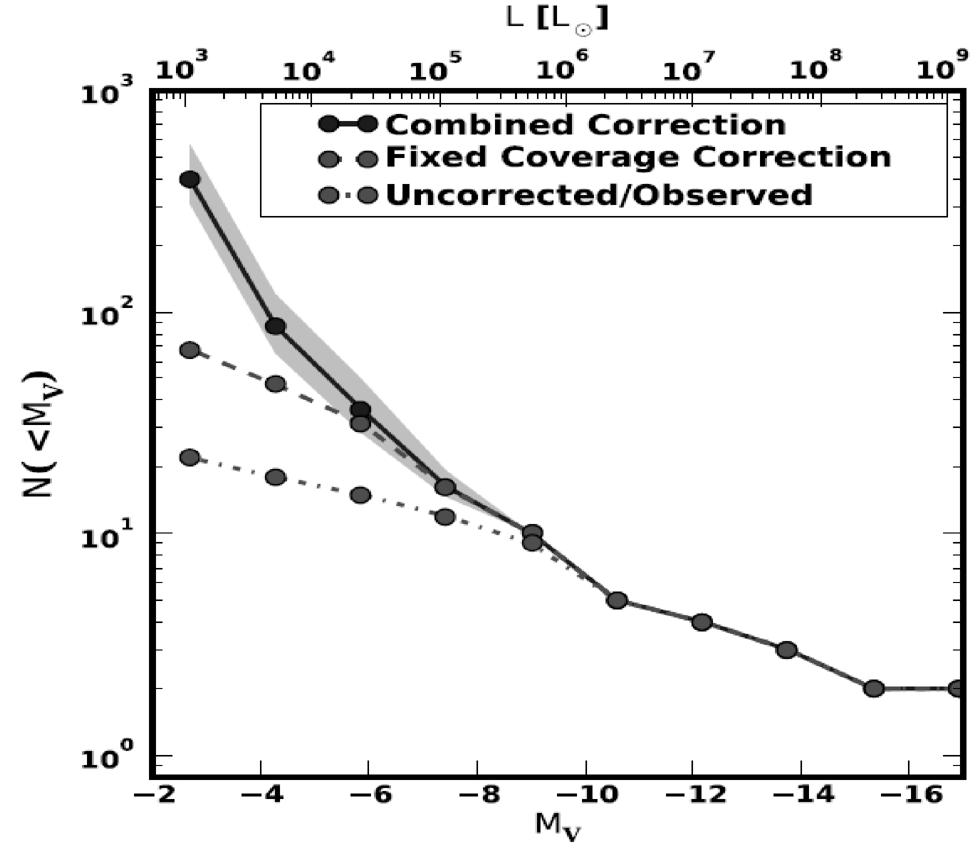

FIG. 6.—Luminosity function as observed (*lower curve*), corrected only for SDSS sky coverage (*middle curve*), and with all corrections included (*upper curve*). Note that the classical (pre-SDSS) satellites are uncorrected, while new satellites have the correction applied. The shaded error region corresponds to the 98% spread over our mock observation realizations. Segue 1 is not included in this correction. [*See the electronic edition of the Journal for a color version of this figure.*]

Tollerud et al. 2008, ApJ, 688, 277

What are the Milky Way satellites telling us about *galaxy formation*?

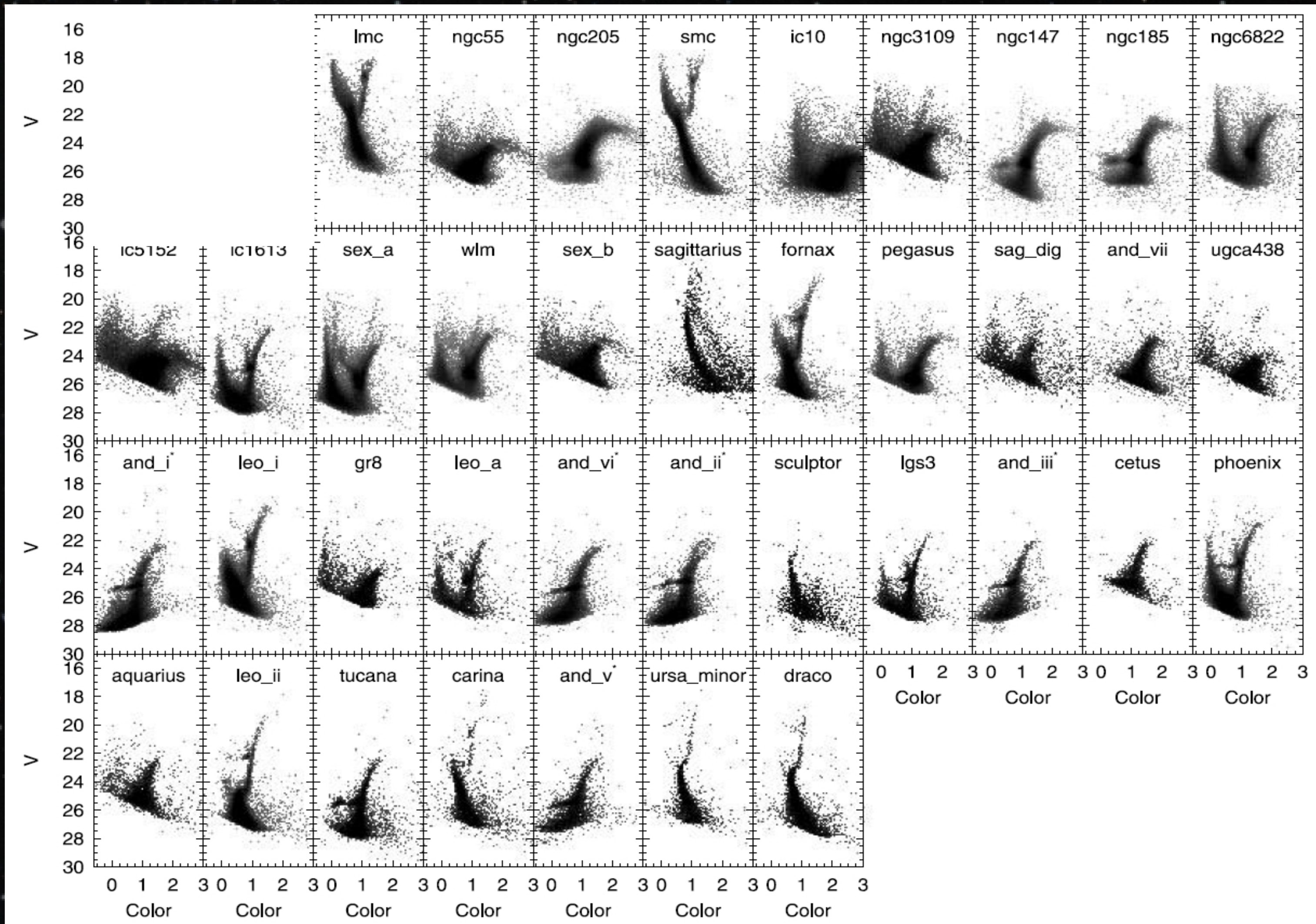

FIG. 7.—Observed color-magnitude diagrams for single fields in each of the Local Group galaxies for which *HST* WFPC2 data have been obtained. Generally, the fields with the deepest exposures or largest number of stars have been chosen. Most of the fields show $V-I$ vs. V, but a few fields use $B-V$ for the abscissa; the latter are indicated with an asterisk after the galaxy name.

Holtzman, Afonso, & Dolphin 2006, ApJS, 166, 534

What are the Milky Way satellites telling us about *galaxy formation*?

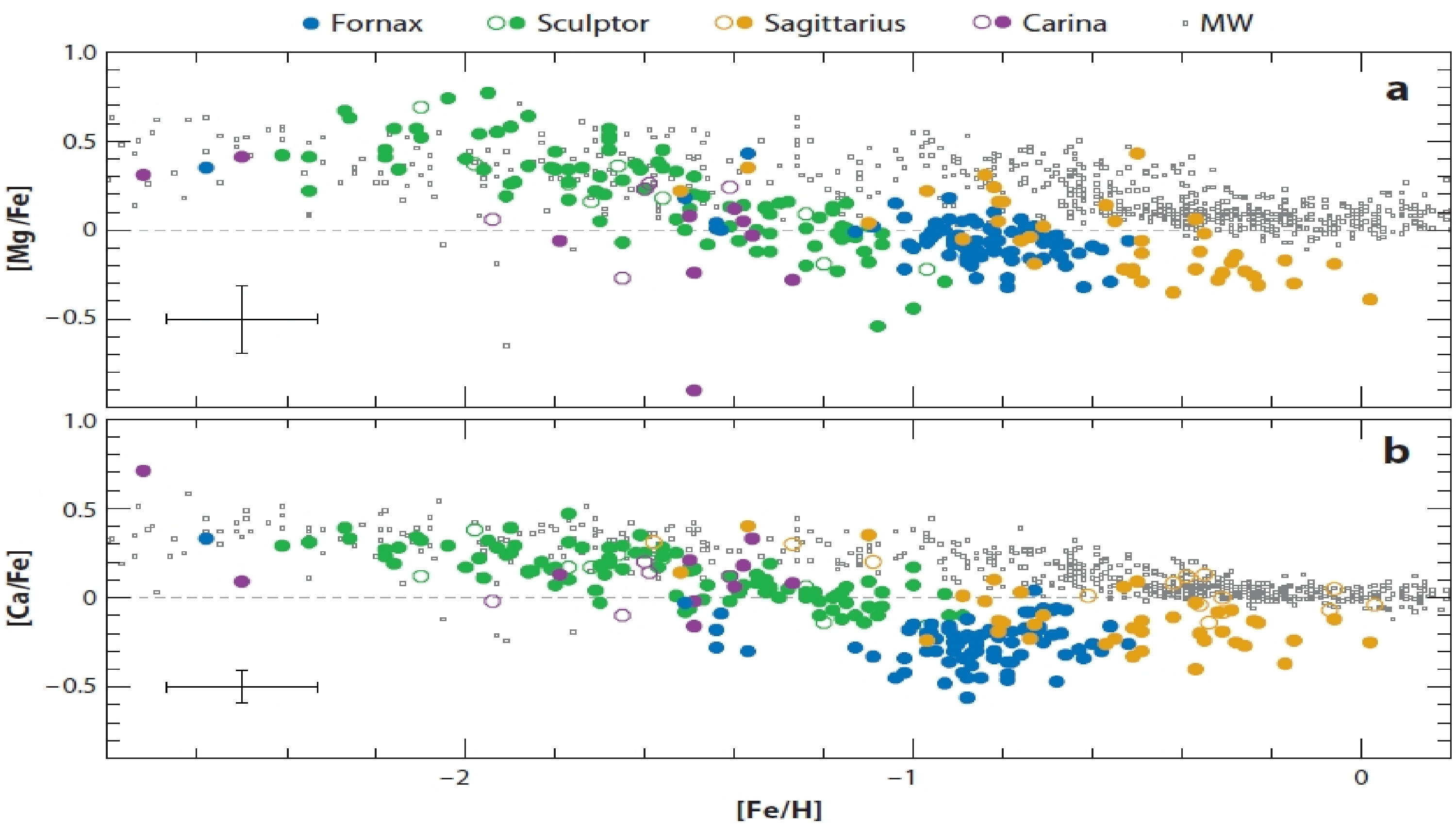

Figure 11

α-elements, (*a*) Mg and (*b*) Ca, in four nearby dwarf spheroidal galaxies: Sgr (*orange*: McWilliam & Smecker-Hane 2005, Monaco et al. 2005, Sbordone et al. 2007), Fnx (*blue*: Shetrone et al. 2003, Letarte 2007), Scl (*green*: V. Hill & DART, in preparation, Shetrone et al. 2003, Geisler et al. 2005), and Carina (*purple*: Shetrone et al. 2003, Koch et al. 2008a). Open symbols refer to single-slit spectroscopy measurements, whereas filled circles refer to multiobject spectroscopy. A representative error-bar for the latter is shown on the left-hand side of the picture. The small gray squares are a compilation of the Milky Way disk and halo star abundances, from Venn et al. (2004a).

Tolstoy, Hill, & Tosi 2009, ARA&A 47 371

What are the Milky Way satellites telling us about *galaxy formation*?

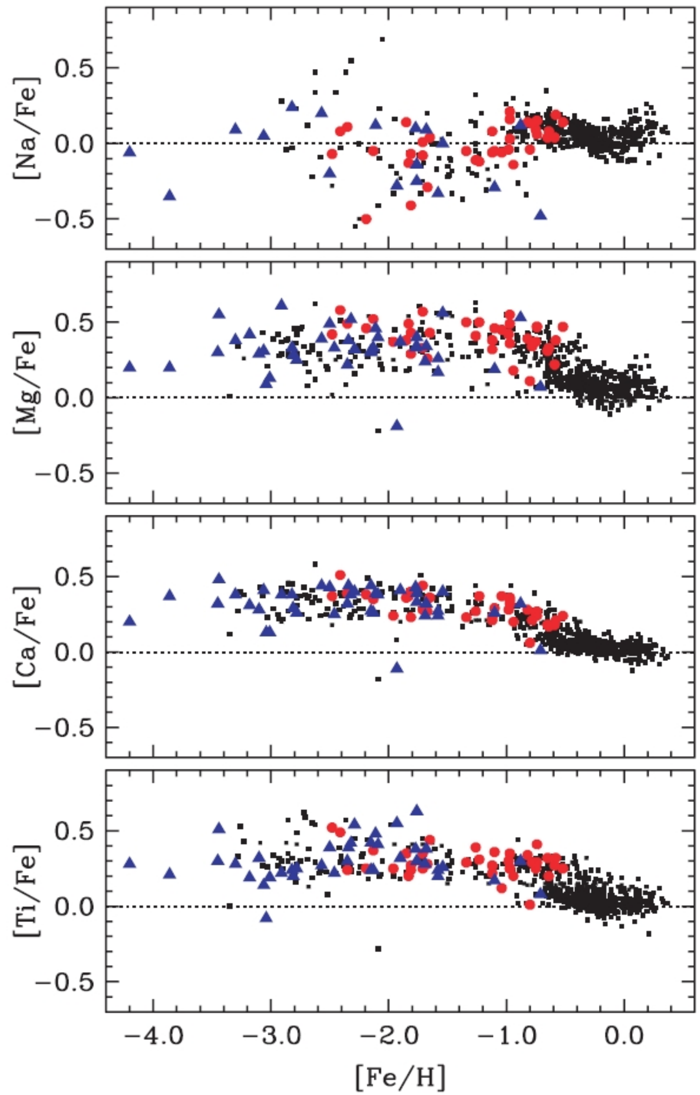

Figure 8. [Na/Fe], [Mg/Fe], [Ca/Fe], and [Ti/Fe] abundance ratios for our inner (dark gray circles, red in the online edition) and outer (black triangles, blue in the online edition) halo populations. Stars that did not meet the kinematic criteria for these two populations are shown as small dots.

Roederer 2009, AJ, 137, 272

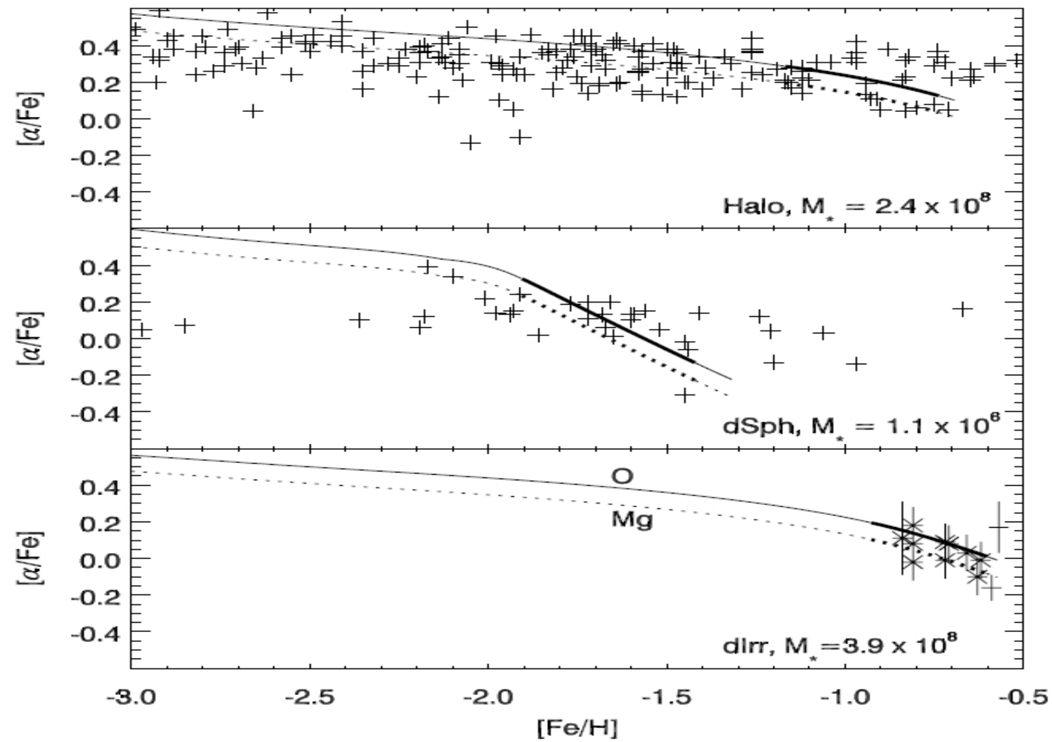

FIG. 3.—[α/Fe] vs. [Fe/H] abundance of our halo progenitor (*top*), dSph galaxy (*middle*), and dIrr-type galaxy (*bottom*). *Top:* The halo-progenitor model retains a supersolar [α/Fe] abundance pattern, resembling the stellar halo data (from Venn et al. 2004; *crosses*). *Middle:* The abundance pattern of the dSph galaxy is set by the strength of the stellar feedback, which forces its [α/Fe] abundance below that of halo stars. For comparison, we overplot abundance data of similarly sized dSph galaxies from Venn et al. (2004) as crosses. *Bottom:* The majority of the star formation in the massive dIrr occurs at near-solar values of [α/Fe] and at higher metallicities, similar to stellar abundances in the SMC (from Venn 1999 and Hill et al. 1995; *stars and crosses, respectively*). Note that we expect extremely metal-poor stars in the SMC and LMC to have enhanced, halo-like [α/Fe] ratios.

Robertson et al. 2005, ApJ 632 872

How does *star formation* depend on *environment*?

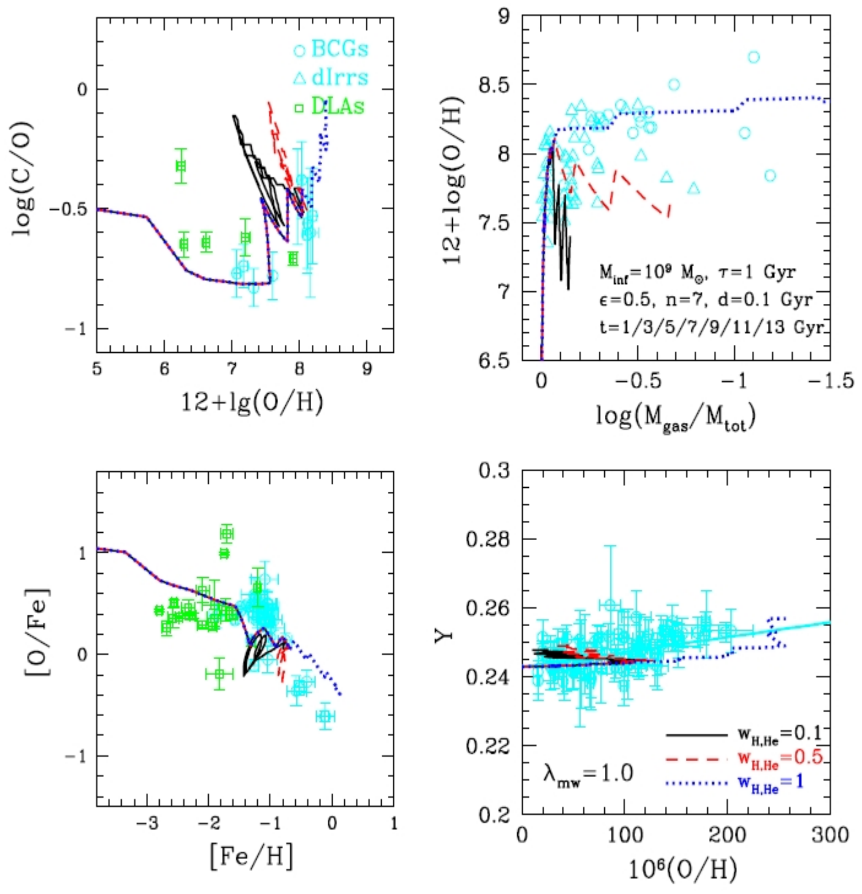

Fig. 10. The evolutionary track as predicted by models with various amounts of metal enhancements. The left two panels are log(C/O) vs. 12+log(O/H) and [O/Fe] vs. [Fe/H]; the right two panels are oxygen abundance vs. gas fraction and Y vs. (O/H). All the 3 models have same bursts sequence ($t = 1/3/5/7/9/11/13$ Gyr, and $d = 0.1$ Gyr for each burst), but different degrees of metal enhancement. The *black-solid lines*, *red-dash lines*, *blue-dot lines* represent $w_{\mathrm{H,He}} = 0.1, 0.5, 1$ respectively. All these models assume the same total infall mass $M_{inf} = 10^9 M_{\odot}$. The observational data are the same as in Fig. 2, Fig. 3 and Fig. 4, BCDs, dIrrs, and DLAs are plotted in *cyan open circles*, *cyan open triangles* and *green open squares* here.

Yin, Matteucci, & Vladilo 2011, A&A accepted arXiv:1102.4197