FULL TITLE
ASP Conference Series, Vol. **VOLUME**, **YEAR OF PUBLICATION**
NAMES OF EDITORS

The Red Halos of Disk Galaxies

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Abstract. Deep optical/near-IR surface photometry of galaxies outside the Local Group have revealed the existence of faint and very red halos around objects as diverse as spirals and blue compact galaxies. The colours of these structures are much too extreme to be reconciled with resolved stellar populations like those seen in the halos of the Milky Way or M31, and alternative explanations like dust reddening, high metallicities or nebular emission are also disfavoured. A stellar population obeying an extremely bottom-heavy initial mass function, similar to that recently reported for the LMC field population, is on the other hand consistent with all available data. Because of its high mass-to-light ratio, such a population would effectively behave as baryonic dark matter and could account for some of the baryons still missing from local inventories. Here, we report on a number of recent developments in this field.

1. The Red Halo Puzzle

Deep optical/near-IR broadband images have revealed very faint halos around both edge-on disk galaxies (Zibetti et al. 2004; Zibetti & Ferguson 2004) and blue compact galaxies (Bergvall & Östlin 2002; Bergvall et al. 2005). These halos, which are detected at surface brightness levels of $\mu_g \approx 28$ mag arcsec^{-2} and $\mu_B \approx$ 26-27 mag arcsec^{-2} respectively, have colours much too red to be reconciled with normal, metal-poor stellar populations like those resolved in the halos of the Milky Way and M31. The nature and origin of these structures remain a mystery.

2. Solution: A Bottom-Heavy Initial Mass Function?

In Zackrisson et al. (2006), we used spectral evolutionary models to put various possible explanations for the red halo colours to the test. The results are quite astonishing: The only scenario capable of explaining the red halos of both disk galaxies and blue compact galaxies is a stellar population obeying an extremely bottom-heavy initial mass function ($dN/dM \propto M^{-\alpha}$ with $\alpha \approx 4.50$, where $\alpha = 2.35$ represents the Salpeter slope). Because of its very high mass-to-light ratio ($M/L_{\mathrm{B}} > 30$), such a population effectively qualifies as baryonic dark

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matter and could help explain the whereabouts of some of the missing baryons in the local Universe.

3. Does the Milky Way Have a Red Halo?

If red halos of low-mass are ubiquitous to disk galaxies (and possibly *all* galaxies), it becomes interesting to ask whether the Milky Way itself could be surrounded by a hitherto undetected halo of low-mass stars with photometric properties similar to that detected around stacked edge-on disks (Zibetti et al. 2004). This could help explain the discrepancy between the seemingly low baryon fraction of the Milky Way halo, compared to the prediction of current cosmological simulations (see e.g. McGaugh 2007, for a review). However, such a structure must then somehow have evaded the faint star counts aimed to constrain the luminosity function of halo subdwarfs. In Zackrisson & Flynn (2008, in preparation) we investigate the red halo constraints imposed by observations of this kind. We find, that while a uniform halo population with an IMF as extreme as that envisioned by Zackrisson et al. (2006) can be safely ruled out, a halo with a strong radial population gradient (with an abnormal fraction of low-mass stars only at large Galactocentric distances) may be more difficult to disqualify.

4. Red Halos of Low Surface Brightness Galaxies

While Zibetti et al. (2004) detected a red halo around stacked high surface brightness disks, Caldwell & Bergvall (2007) have carried out a similar stacking of low surface brightness disks from the SDSS. Not only have they discovered a red halo, but this structure is even redder than previous detections - thereby strengthening the case against a normal stellar population. A careful assessment of the SDSS point-spread function furthermore indicates that this red halo cannot possibly be explained as a spurious structure caused by point spread function effects.

Acknowledgments. EZ acknowledges research grants from the Swedish Research Council, the Academy of Finland and the Swedish Royal Academy of Sciences. CF acknowledges support from the Academy of Finland.

References

Bergvall, N., & Östlin, G. 2002, A&A, 390, 891

Bergvall, N., Marquart, T., Persson, C., Zackrisson, E., & Östlin, G. 2005, in Multi-wavelength Mapping of Galaxy Formation and Evolution, ed. A. Renzini. & R. Bender (Berlin: Springer-Verlag), p. 355

Caldwell, B., & Bergvall, N. 2007, in Galaxy Evolution Across the Hubble Time, ed. F. Combes & J. Palous, Cambridge University Press, p. 82

McGaugh, S. S., to appear in Dark Galaxies and Lost Baryons, ed. J. Davies & M. Disney, Cambridge University Press (preprint arXiv: 0707.3795)

Zackrisson, E., Bergvall, N., Östlin, G., Micheva, G., & Leksell, M. 2006, ApJ 650, 812

Zibetti, S., White, S. D. M., & Brinkmann, J. 2004, MNRAS, 347, 556

Zibetti, S., & Ferguson, A. M. N. 2004, MNRAS, 352, 6