By Alan Heavens, but presented by the “victim”

How (not) to write a research proposal

The Panel

- Are the panel specialists? Probably not.
  - E.g. large difference between ERF and URF
- Do they have a zillion proposals to read? Probably.
- Do you need to end up in the top say 10%? Probably yes.
- Do they need to be told why you are doing this? Yes.

Case Study

- Proposal is Peder Norberg's STFC Advanced Fellowship (e.g. ERF) proposal from a few years ago
  - Signs of accomplishment (2+ years after Ph.D.)
  - Independent researcher
  - Leadership
  - Grand vision
  - Esteem

- It came close (~12 awards from c. 200 applications)

The halo mass function and the evolution of Dark Energy[1]

The 2 degree Field Galaxy Redshift Survey (2dFGRS; **Colless et al. 2001**) and the Sloan Digital Sky Survey (SDSS; Adelman-McCarthy et al. 2007) have transformed our view of large scale structure in the low redshift Universe, reinforcing the standard cosmological model (ΛCDM): a flat, Dark Energy dominated collisionless Cold Dark Matter model (e.g. **Cole et al. 2005**). The Galaxy And Mass Assembly (GAMA) redshift survey and the multi-band 3/4-sky imaging survey Pan-STARRS are the next generation of galaxy surveys after 2dFGRS and SDSS. As Co-PI of GAMA and member of Pan-STARRS, my aim with this fellowship is to address two major questions on dark matter and Dark Energy, left open by previous surveys:

- determine the dark matter halo mass function using a galaxy group catalogue constructed from the deep and wide GAMA survey, testing a key CDM model prediction.
- measure the evolution of Dark Energy, by quantifying the galaxy - mass relation with Pan-STARRS using clustering estimators optimised for photometric redshift data.

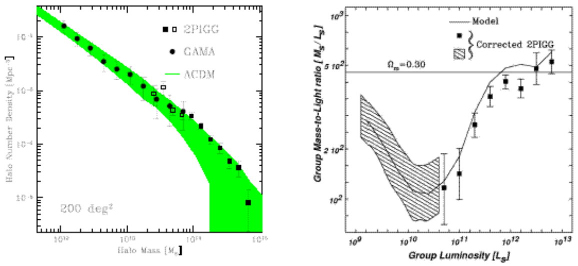

Figure 1: *Left:* Halo mass function comparisons: simulated GAMA survey (circles), 2PIGG data (squares) and ΛCDM theory (shade). *Right:* The dynamical 2PIGG group mass-to-light ratio, tracer of galaxy formation efficiency, as function of group luminosity (squares). The shaded area assumes ΛCDM theory: GAMA is designed to precisely probe that low mass regime. Adapted from Eke et al. (2006).

I. Halo mass function and galaxy formation efficiency at $z \simeq 0$

The comparison of robust model predictions with empirical galaxy clustering measurements on scales of a few to tens of Mpc (e.g. **Norberg et al. 2001**, **Baugh et al. 2004**, Zehavi et al. 2005) confirms the basic CDM paradigm for the growth of structure. However, on sub-Mpc scales (i.e. on the scales of groups and galaxies) our theoretical understanding is less well-founded. The kpc to Mpc range is the key scale over which the baryons and baryon physics become critical to our understanding of the structures we see. A fundamental test of the currently favoured CDM paradigm of hierarchical structure formation is to measure the accurately predicted dark matter halo mass function over a large mass range and timespan. This is precisely the main aim of the 200 □° 'Galaxy And Mass Assembly' (GAMA) survey and the principal goal of this proposal, i.e. to provide with GAMA the ultimate test confirming or rejecting the currently favoured cosmological structure formation model.

[1] Citations in bold font refers to co-authored papers

At any redshift, the dark matter halo mass function, dn/dM, is well established via detailed numerical simulations, requiring no knowledge of the baryonic physics, and is precisely predicted over 5 orders of magnitude in halo mass (e.g. Jenkins et al. 2001, Springel et al. 2005). With the cosmological parameters now specified to high accuracy in the post-WMAP era (e.g. **Sanchez et al. 2006**, Spergel et al. 2007), this theoretical prediction of the CDM paradigm is one of the most robust available. Observationally, halo masses can be derived through dynamical mass estimates of galaxy groups. An attempt at this was made with 2dFGRS and the statistical 2PIGG group catalogue (**Eke et al. 2004**; see Berlind et al. 2006 for a SDSS study). While 2PIGG is able to probe dn/dM down to a few $\times 10^{13}$ $M_{\odot}$ (Eke et al. 2006), the catalogue is incomplete below 10^{14} $M_{\odot}$, so we can test only the theoretical prediction over less than one order of magnitude in mass (Fig. 1A). They are limited also to one epoch only, as no survey is yet deep and large enough to obtain reliable halo mass function estimates for two epochs.

Starting in March 2008 for 3 years on the AAT, the GAMA[2] survey represents a germane connection between the shallow, wide (6dFGS, SDSS, 2dFGRS) and the deep, narrow (VVDS, DEEP2) galaxy redshift surveys that have recently been completed or are currently underway. By going ~ 10 times deeper in both r and K, w.r.t. the SDSS spectroscopic and the 2MASS imaging surveys, and doubling the spectral resolution w.r.t. 2dFGRS, the main limitations of current dn/dM estimates are overcome. The extra depth increases the number of group members by a factor of a few and the higher spectral resolution enables the detection of significantly lower mass groups. GAMA will provide statistically robust halo mass measurements down to a few $\times 10^{12}$ $M_{\odot}$, about two orders of magnitude improvement over 2PIGG.

With this new statistical group catalogue, predictions from current galaxy formation models for their feedback mechanisms and their star formation efficiency will be addressed. The latter is predicted to increase with declining group mass down to Local Group sized haloes, below which the efficiency is expected to decrease. Currently, this regime of maximum efficiency and what happens within the smaller haloes is completely unknown (Fig. 1B). With GAMA, feedback mechanisms in low mass haloes will be probed statistically for the first time. This puts stringent constraints on recent semi-analytic galaxy formation models (e.g. De Lucia et al. 2006, Bower et al. 2006), predictions of which vary significantly at these low halo masses: only GAMA is able to measure the galaxy formation efficiency in this regime.

II. Optimal galaxy clustering estimates for photo-z surveys

Coincident to the establishment of the ΛCDM concordance cosmology, questions about the evolution of the Dark Energy equation of state are raised. Theoretically Dark Energy is rather poorly understood, and currently constraints on its nature are expected to come from astronomical observations. This has indirectly motivated the planning and construction of several international surveys, like WiggleZ, VST-KIDS, or Pan-STARRS (see e.g. Peacock et al. 2006). The already funded 'Panoramic Survey Telescope and Rapid Response System' PS1 (Pan-STARRS) has as foremost cosmological aim to constrain the evolution of Dark Energy by detecting the baryonic acoustic oscillations and using geometrical techniques. However, this can only be achieved once any scale and galaxy property dependent clustering bias is precisely determined, an integral aim of this proposal, i.e. to optimally model the galaxy - mass relation with Pan-STARRS and put new galaxy formation constraints for $z \lesssim 1$.

Between 2008 and 2012, Pan-STARRS PS1, with its dedicated telescope and 7 □° 1.4 Gpixel camera, will survey 3/4 of the sky in 5 bandpasses (g, r, i, z & y) to ~ 10 times the depth of the SDSS imaging survey and ten 7 □° fields spread uniformly across the sky ~ 200 times deeper, all to an exquisite *rms* absolute photometric precision. Traditionally, accurate galaxy clustering measurements on scales of a few Mpc are done with redshift surveys (e.g. 2dFGRS, SDSS, DEEP2). With numerous large multiband imaging surveys, photometric redshifts, known also as photo-z, are commonly used in clustering studies, mainly to split samples in distinct redshift slices (e.g. COMBO-17, CFHTLS). Photo-z are best described as distribution functions with widths critically depending on the bands used and the galaxy type considered. The expected Pan-STARRS *rms* photo-z accuracy is $\lesssim 3$ % for red galaxies, but significantly larger for blue ones. This limitation is inherent to photo-z estimators using fits to spectral energy distributions with galaxy templates and/or synthetic stellar population models (e.g. Bolzonella et al. 2000), but can be overcome, at a certain price, with Bayesian photo-z estimators (e.g. Benitez 2000).

[2] The team is led by Dr. S.P. Driver, together with six Co-PIs (including Dr. P. Norberg), three survey consortiums (UKIDSS, KIDS, VIKING), and about 15 associate members.

Due to the survey size, statistical errors will be dwarfed by systematic errors, arising from not using the photo-z distribution. This is particularly important for samples with heterogeneous photo-z accuracies. For real space clustering estimates, careful modelling is needed in extracting the relevant information from redshift space and photo-z distorted clustering patterns. Additionally, optimal galaxy formation constraints require appropriate redshift splits of the data. With wide photo-z distributions, large redshift slices w.r.t. typical redshift uncertainties are not practical, nor accurate enough w.r.t. the expected Pan-STARRS statistical accuracy. Hence statistical estimators accounting for the full photometric redshift information available have to be developed and tested. With properly understood Pan-STARRS clustering measurements, appropriate analysis techniques to constrain the models are needed, together with detailed error calculations, including statistical and systematic errors.

New statistical analysis methods are required to accurately constrain galaxy formation models with Pan-STARRS. To properly understand and model systematic biases in different galaxy samples is key for the precision required for the baryonic acoustic oscillations studies. These new techniques will be essential for future planned photo-z surveys, like DES and LSST.

III. The similar needs of the GAMA and Pan-STARRS science goals

Within the GAMA and Pan-STARRS collaborations, team members have already taken on the responsibility to develop and share certain key-infrastructures, like the construction of the catalogues, the survey completeness maps and the associated idealised mock galaxy catalogues.

Building on the extensive experience acquired with 2dFGRS, in particular in the characterisation of the survey selection function (**Norberg et al. 2002**), my GAMA infrastructure contribution is to lead the construction of the survey completeness masks, key for all statistical analyses. Similarly, I am part of the group that models the Pan-STARRS selection functions.

The perfect mocks are created from large high-resolution N-body simulations and populated with galaxies according to semi-analytic galaxy formation, halo occupation or conditional luminosity function models (e.g. Bower et al. 2006; Cooray & Sheth 2002; Yang et al. 2003). These idealised mocks have to be degraded so to mimic the surveys with highest possible accuracy, including even their defaults. The different stages of mock surveys, from perfect to 'observed', are essential in developing statistical tools, in understanding the survey selection function and finally in interpreting the measurements. Within GAMA, I lead this theoretical modelling.

These infrastructures are key for the science goals of this proposal and those of the surveys.

References: Adelman-McCarthy J.K. et al., 2007, ApJS, 172, 634; **Baugh C.M. et al.**, 2004, MNRAS, 351L, 44; Benitez N., 2000, ApJ, 536, 571; Berlind A. et al., 2006, ApJS, 167, 1; Bolzonella M. et al., 2000, A&A 363, 476; **Colless M. et al.**, 2001, MNRAS, 328, 1039; **Cole S. et al.**, 2005, MNRAS, 362, 505; Cooray A. & Sheth R., 2002, PhR, 372, 1; De Lucia et al., 2006, MNRAS, 366, 499; **Eke V.R. et al.**, 2004, MNRAS, 348, 866; Eke V.R. et al., 2006, MNRAS, 370, 1147; Jenkins A. et al., 2001, MNRAS, 321, 372; **Norberg P. et al.**, 2001, MNRAS, 328, 64; **Norberg P. et al.**, 2002, MNRAS, 336, 907; Peacock J.A. et al., 2006, astro-ph/0610906; **Sanchez A.G. et al.**, 2006, MNRAS 366, 189; Spergel D.N. et al., 2007, ApJS, 170, 377; Springel V. et al., 2005, Nature, 435, 629; Yang X. et al., 2003, MNRAS, 339, 1057; Zehavi I. et al., 2005, ApJ, 630, 1.

Abstract

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The 2 degree Field Galaxy Redshift Survey (2dFGRS; **Colless et al. 2001**) and the Sloan Digital Sky Survey (SDSS; Adelman-McCarthy et al. 2007) have transformed our view of large scale structure in the low redshift Universe, reinforcing the standard cosmological model (ΛCDM): a flat, Dark Energy dominated collisionless Cold Dark Matter model (e.g. **Cole et al. 2005**). The Galaxy And Mass Assembly (GAMA) redshift survey and the multi-band 3/4-sky imaging survey Pan-STARRS are the next generation of galaxy surveys after 2dFGRS and SDSS. As Co-PI of GAMA and member of Pan-STARRS, my aim with this fellowship is to address two major questions on dark matter and Dark Energy, left open by previous surveys:

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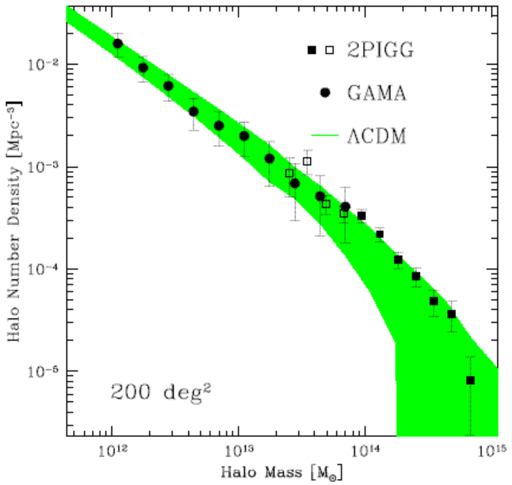
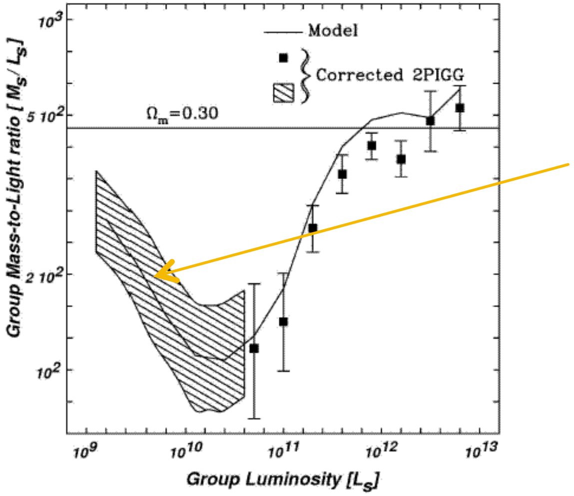
- Diversion
- Too many references (>0)
- Too low-key
  - *2dF was really important*
- Where is the big picture?
- What is the main science goal?

Confrontation of theory and observation

- This is good





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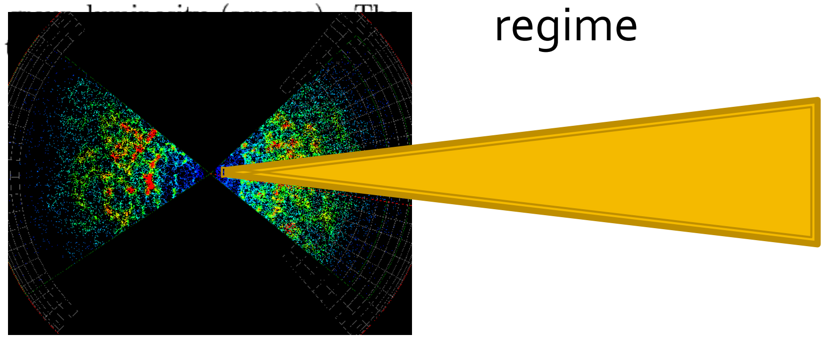

Standard theory may have problems on small scales

Why fund now?

Only GAMA can probe this regime

Don’t be too low-key

II. Optimal galaxy clustering estimates for photo-z surveys

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75% of the Universe is in an unknown form, Dark Energy, and it’s WEIRD…

Talk yourself up, not down

Accentuate the things you lead

- I am co-PI of the GAMA survey, and I lead the … analysis.
- I have responsibility for delivering…
- I was invited to lead…
- I recognised the capability of… and proposed…
- NOT 'I am involved in…'

Be focussed, not woolly

measurements on scales of a few Mpc are done with redshift surveys (e.g. 2dFGRS, SDSS, DEEP2). With numerous large multiband imaging surveys, photometric redshifts, known also as photo-z, are commonly used in clustering studies, mainly to split samples in distinct redshift

- Say how you will tackle a problem, don't just say what the problem is

terms. Additionally, optimal galaxy formation constraints require appropriate redshift splits of the data. With wide photo-z distributions, large redshift slices w.r.t. typical redshift uncertainties are not practical, nor accurate enough w.r.t. the expected Pan-STARRS statistical accuracy. Hence statistical estimators accounting for the full photometric redshift information available have to be developed and tested. With properly understood Pan-STARRS clustering measurements, appropriate analysis techniques to constrain the models are needed, together with detailed error calculations, including statistical and systematic errors.

New statistical analysis methods are required to accurately constrain galaxy formation models with Pan-STARRS. To properly understand and model systematic biases in different galaxy samples is key for the precision required for the baryonic acoustic oscillations studies. These new techniques will be essential for future planned photo-z surveys, like DES and LSST.

Help the assessors get their heads round what you plan to do

- Headings should act as aides-memoire, and science-driven

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I. Halo mass function and galaxy formation efficiency at $z \simeq 0$

II. Optimal galaxy clustering estimates for photo-z surveys

III. The similar needs of the GAMA and Pan-STARRS science goals

If they understand it, they may have a strong opinion on it (good or bad…) but confusion will probably not put you at the top…

Potential weaknesses: how to handle them

- Peder had >6000 citations, but had no first-author paper from 2002-2007
- How should you handle that? Tricky judgement
- I'm not sure, to be honest. My (current) advice would be:
- Don't draw explicit attention, but maybe mention somewhere the publication policy – Peder is in the first few authors (i.e. those who did the work) in 6 of the 8 highest-cited 2dF papers.
- Try to give a panel member who favours you (if there is one) a response if the weak point is raised.

Summary

- Start with the big picture - remember that most assessors will not be specialists
- Emphasize your role, especially leading
- Why you?
- Why now?
- Include indicators of esteem
- Does it fit in with Research Council strategy?
- Make it clear what the main points are
- If there is a weakness which might raise a question, consider including an answer obliquely in the proposal (somewhere)