ERC Starting Grant 2015
Research proposal [Part B1][1]
(Part B1 is evaluated both in Step 1 and Step 2
Part B2 is evaluated in Step 2 only)

Evolving Galaxies in a Dark Universe

GALDARK

Cover Page:

- Name of the Principal Investigator (PI): Dr Alexie Leauthaud
- Name of the PI's host institution for the project: Centre de Recherce Astrophysique de Lyon (CRAL)
- Proposal duration in months: 60

A fundamental goal in observational cosmology is to understand the link between the luminous properties of galaxies and the dark matter halos in which they reside. A precise understanding of the key mechanisms that determine the growth, evolution, and global properties of galaxies has eluded astronomers for more than half a century. Dark matter is thought to play a key role in setting the conditions that determine galaxy properties but the exact details of how dark matter influences galaxy formation remains a topic of active debate. The goal of GALDARK is to understand the interplay between the dark and bright universe and to shed light on the following questions. What is the co-evolution between dark matter and galaxy formation? What is the distribution of dark matter on small and large scales? How do these distributions compare with predictions from the LCDM cosmological model? We will tackle these questions over scales that range from galaxy scales (tens of kpc to 100 kpc) to scales comparable to the sizes of dark matter halos (hundreds of kpc to a Mpc). Our large-scale investigation will be based on state-of the art measurements of weak gravitational lensing and galaxy clustering from the HSC, BOSS, and eBOSS surveys. Our small scale component is a novel and potentially ground-breaking direction of research that aims to revolutionize our understanding of the galaxy dark-matter connection on scales of a few tens of kpc by combining weak lensing measurements with dynamical masses measured via resolved Integral Field Unit Spectroscopy from the MaNGA survey. By tackling both small and large scales, GALDARK will address a set of different, but inter-related questions with the aim of providing a complete and holistic view of the link between galaxies and dark matter. This frontier research will have a wide ranging impact and will also train and develop a group of scientists with key tools and skills necessary for ESA's ambitious Euclid mission in 2020.

[1] Instructions for completing Part B1 can be found in the '*Information for Applicants to the Starting and Consolidator Grant 2015 Calls'*.

Section a: ***Extended Synopsis of the scientific proposal (max. 5 pages)***

The Co-evolution of Galaxies and Dark Matter from Small to Large Scales

A fundamental goal in observational cosmology is to understand the link between the luminous properties of galaxies and the dark matter halos in which they reside. A precise understanding of the primary mechanisms that determine the growth, evolution, and global properties of galaxies has eluded astronomers for more than half a century. Galaxies are thought to grow and evolve via two main channels: either directly via the conversion of gas into stars, or by accreting other neighboring galaxies via a process known as "merging". Both of these processes are intimately linked to the local dark matter environment in which galaxies are embedded. Because galaxies are trapped deep within the potential wells of massive dark matter halos, accretion processes (fresh supplies of gas as well as accretion by other galaxies) are primarily dark matter driven. For these reasons, dark matter is thought to play a key role in setting the conditions that determine galaxy properties. However, the exact details of how dark matter influences galaxy formation, and in turn, how galaxy formation modifies dark matter distributions, is a topic of active investigation and debate.

The goal of GALDARK is to understand the interplay between the dark and bright universe and to shed light on questions such as: 1) what is the co-evolution between dark matter and galaxy formation? How does dark matter influence galaxy formation processes and in turn, do baryonic physics affect the dark matter distribution? 2) What is the distribution of dark matter on both small scales and large scales? How do these distributions compare with predictions from the λCDM model? We will tackle these questions by investigating the galaxy-dark matter connection over a broad range of physical scales ranging from galaxy scales (tens of kpc to 100 kpc) to scales comparable to the sizes of dark matter halos (100 kpc to a Mpc). *By tackling both small and large scales, GALDARK will address a set of different, but inter-related questions with the aim of providing a complete and holistic view of the link between galaxies and dark matter.*

The Large Scale (R>200 kpc) Connection between Galaxies and Dark Matter. The large-scale connection between galaxies and dark matter provides us with insight about how galaxies grow (or do not grow) in relation to their global reservoirs of fuel. This connection is typically investigated by mapping out the average relationship between a given galaxy property and host halo mass. In the last five years, there has been a tremendous interest in pinning down the relationship between halo mass, M_{halo}, and galaxy mass, M_*, as demonstrated by a flurry of recent publications (e.g, Shankar et al. 2014, Velander et al. 2014, Hudson et al. 2015). I pioneered early work in this field with a study that has now become a leading reference in this domain (Leauthaud et al. 2011, 2012). GALDARK will employ two complementary techniques to probe the large-scale galaxy-dark matter connection: *galaxy-galaxy lensing* which uses weak gravitational lensing to probe the gravitational potential around foreground ("lens") galaxies and *galaxy clustering*. The weak lensing component of GALDARK will be measured using the HSC survey (of which I am a member): a truly ambitious multi-wavelength (g,r,i,z,y) weak-lensing program to map out 1400 square degrees of the sky with the 8.2m Subaru Telescope to i~26 mag. The HSC survey began collecting data in the spring of 2014 and will continue to do so for 5-6 years. Clustering measurements for GALDARK will include angular clustering using photometric samples from HSC as well as higher signal-to-noise clustering measurements based on spectroscopic samples from the Baryon Oscillations Spectroscopic (BOSS) and the Extended Baryon Oscillations Spectroscopic (eBOSS) surveys. We will make extensive use of these samples in GALDARK with the goal of harnessing the tremendous statistical power of BAO surveys to extract a maximum amount of information about the galaxy-halo connection

While both weak lensing and clustering are powerful techniques in their own right, significant gains can be made by using a joint analysis of both measurements. I performed the first joint analysis of galaxy clustering and galaxy-galaxy lensing in order to constrain the global M_{halo}-M_* relation to z=1 (Figure 1, Leauthaud et al. 2012). In Tinker et al. (2013), we extended this work to include star-formation in addition to stellar mass. While convincing evidence at z=0 suggests that at fixed stellar mass, star-forming galaxies live in lower mass halos than quenched galaxies (e.g., Mandelbaum et al. 2006), our results revealed the unexpected and highly intriguing result that this trends is inverted at higher redshifts. Our results suggest that at z=0.5, star forming galaxies live in massive galaxies than quenched galaxies! These types of observations have strong consequences for models of galaxy formation (see discussion in Tinker et al 2013).

With upcoming data sets such as the HSC survey, we will be able to bin the data into much finer bins and to reveal this connection in exquisite detail. GALDARK will represent the next major leap forward in this field that will be enabled by combining new high-signal-to noise weak lensing measurements (with vastly expanded capabilities compared to COSMOS) and clustering measurements from large galaxy samples collected by BAO surveys. I have a strong experience with this topic with leading observational as well as theoretical papers in this field (Leauthaud et al. 2011, 2012, 2014).

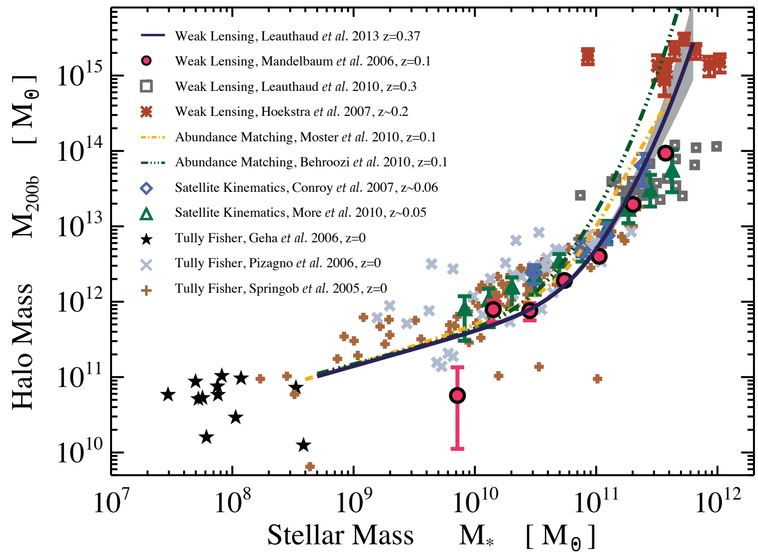

Figure 1: The relationship between halo mass M_{halo} and stellar mass M_* at z~0.3 as measured by combining galaxy-galaxy lensing, galaxy clustering, and the galaxy stellar mass function in the COSMOS survey (blue solid line). The unique depth of the COSMOS data allowed us to probe the evolution of this relationship out to z~1 (Leauthaud et al. 2012). In this work, for the first time, we robustly measured the redshift evolution of the halo mass scale at which galaxy growth is maximally efficient.

The Small Scale (R~20 kpc) Connection between Galaxies and Dark Matter. The small-scale component of GALDARK is a novel and potentially groundbreaking direction of research that aims to revolutionize our understanding of the galaxy dark-matter connection on very small scales (a few tens of kpc to a few hundred kpc). On small scales, the comparison between the stellar profiles of galaxies and their total profiles contains key clues about the processes by which galaxies acquire mass in respect to dark matter. The interplay between baryons and dark matter on these scales is sensitive to a variety of processes, including but not limited to, adiabatic contraction, dynamical friction from in-falling satellites, and feed-back from Active Galactic Nuclei (AGN). A powerful approach to constrain the total density profile of galaxies on scales of about 5-10 kpc is to combine stellar kinematics with measurements of strong gravitational lensing (e.g., Newman et al. 2013; Sonnenfeld et al. 2014). However, strong lensing systems are rare and are primarily limited to massive early type galaxies at intermediate redshifts. I propose to explore the possibility of using weak lensing measurements on small scales to potentially overcome these limitations and to probe the total density profiles of galaxies over a wide range in redshift and stellar mass.

Current constraints on dark matter density profiles from weak lensing are typically limited to radial scales greater than R>50 kpc. On smaller scales, there is a paucity of source ("background") galaxies due to poor image quality ("seeing") and complicating effects such as isophotal blending that inhibits shape measurements. With my graduate student Masato Kobayashi we have investigated these effects and shown that 90% of source galaxies are lost on small scales due to proximity effects. This prohibits small-scale weak lensing measurements with current surveys but the next generation of weak lensing surveys will have enough statistics that even after rejecting 90% of the source galaxies, the remaining 10% will be sufficient to perform high S/N measurements. Our calculations for Euclid show that after a conservative selection (e.g., rejecting all blends), there are enough "clean" background galaxies to measure the total mass profile at three times the half-light radius (Figure 2). We predict that the signal-to-noise on this type of measurement will be greater than S/N=20 at R=20 kpc and for galaxies with log(M*)>10 and at z<1. Figure 2 clearly shows that the tremendous power of upcoming weak lensing survey will open up a new window for the exploration of the small-scale galaxy-halo connection. The small-scale component of GALDARK will aim to address the technical challenges of performing un-biased small-scale weak lensing measurements. At the same time, in parallel, GALDARK will also gain valuable experience in this new arena by tackling the "low-hanging fruit", namely, massive BCGs at very low redshifts (z<0.1). Indeed, there are multiple non-negligible advantages to beginning this work with massive galaxies at low redshifts. First, at low redshifts, the weak lensing signal is less sensitive to systematic errors from photoz's (most faint galaxies are far behind the lens). Second, the signal-to-noise for these types of studies is maximized for massive galaxies at very low redshifts owing to two facts: a) at lower redshifts there are more background galaxies to perform lensing measurements and b) a fixed physical radial separation corresponds to a larger angular separation at low redshifts (which again leads to a larger number of background galaxies). Finally, at low redshift we will be able to obtain high-quality resolved kinematics for BCGs out to large radii (>1.5 R_e) with reasonable amounts of telescope time.

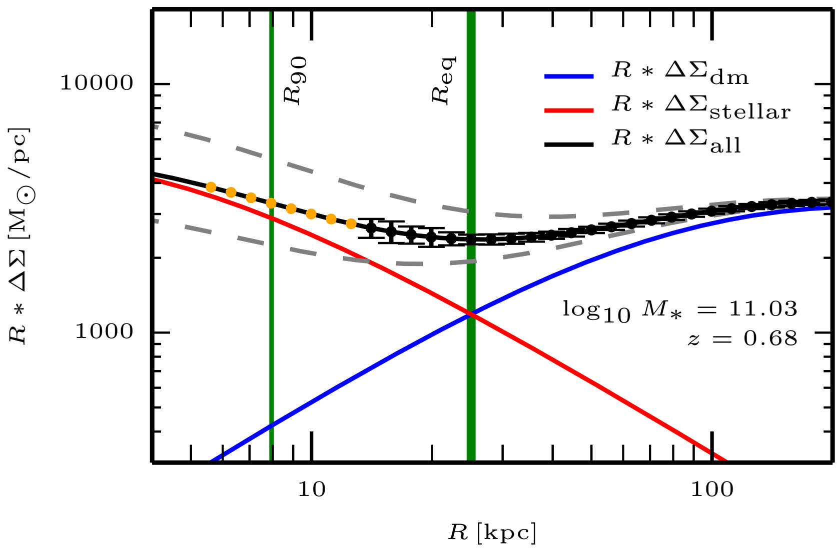

Figure 2: prediction for the small scale lensing signal (log(M*)=11.03 and bin width of 0.07 dex) for Euclid. The vertical scale is multiplied by R to highlight the error bars. Grey dashed lines show the lensing profile when M* is varies by 0.2dex (current uncertainty on the IMF). These measurements will place tight constraints on the IMF and on the inner dark matter slope and will enable studies of the galaxy-halo connection in regimes that are not accessible via strong lensing.

Objectives

The specific goals of GALDARK are to address the following set of key questions:

- *LS-A – What is the mapping between galaxy stellar mass, star-formation rate, and halo mass?*
- *LS-B – Is there a connection between the properties of central galaxies and halo accretion rates?*
- *LS-C – Is halo mass the primary variable for understanding the galaxy-halo connection?*
- *SS-A – Can we use weak lensing to probe the very inner regions of dark matter halos?*
- *SS-B – Can we disentangle the inner dark matter slope from the normalization of the stellar IMF by combining stellar kinematics with stacked weak lensing?*
- *SS-C – Is there a connection between the inner slope of the dark matter distribution and the assembly of stars in BCGs?*

Methodology

Both the small-scale and the large-scale goals described in the previous section will be addressed by harnessing the power of new state-of-the art surveys. A large fraction of our analysis will be based on the HSC multi-wavelength weak lensing survey, the MaNGA Integral Field Unit (IFU) survey of local galaxies, and the BOSS and eBOSS BAO surveys.

<u>The goals of our large-scale component will be achieved via two approaches:</u>

1. The first approach is to combine lensing measurements with clustering measurements using spectroscopic galaxy samples from BOSS/eBOSS. The advantage here is that the availability of spectroscopic redshifts leads to high signal-to-noise clustering measurements ($w_p(r_p)$ as opposed to $w(\theta)$) and also reduces systematic errors in galaxy-galaxy lensing measurements. From a galaxy-halo perspective, the downside to these samples is that the selection functions are optimized for BAO survey and need to be characterized in detail. In sum, these measurements will be highly reliable but the theoretical modelling will be more challenging (see work-package WP3). This is as issue goal LS-A, however, this is not an important issue for goals LS-B and LS-C.
2. The second approach, which is more challenging, will be to analyse clustering ($w(\theta)$ in this case) and lensing measurements for stellar mass selected samples from the HSC survey using photometric redshifts. The main difficulty with this approach will be to understand and characterize the systematic effects introduced by using photometric redshifts instead of spectroscopic redshifts. Instead of just relying on SED fitting techniques, we will actively explore how to improve redshift estimators via cross-correlations with spectroscopic samples. This is a new promising approach that can be used to infer the redshift probability distribution for a single galaxy (Menard et al. 2013, Rahman et al. 2014). Because HSC fully overlaps with SDSS, BOSS, and partially overlaps with eBOSS, there are a tremendous amount of spectroscopic redshifts that can be used to apply this technique.

<u>The goals of our small-scale component will be achieved via two approaches:</u>

1. The first approach will be to combine stacked gravitational lensing measurements with stellar dynamics from the MaNGA survey. In collaboration with Jenny Greene (Princeton), we have recently been awarded time to observe 200 BCGs with IFU spectroscopy as part of a MaNGA ancillary program. This ancillary program will provide resolved spectroscopy for 200 BCGs out to r>1.5Re. Weak lensing from the HSC survey will pin down the outer dark matter profile.
2. The MaNGA program will be extended by a follow-up survey of 50 BCGs in the most massive clusters at z=[0.1,0.2] with MUSE on the VLT and with the ACS camera on the HST. MUSE and ACS have matched field-of-views of one arc-minute, which corresponds to a physical transverse distance of 100-200 kpc at z=0.15. This is well suited for the small scales studies proposed in this research program. This survey will improve on our current MaNGA program in several key aspects. First, MUSE will provide deeper and higher resolution spatially resolved kinematics than MaNGA. Deeper observations will enable dynamical measurements out to larger radii (r>2Re). Second, the HST imaging will provide a higher number of source (background) galaxies that can be used for weak lensing (we expect a factor of 2 increase in the S/N of the weak lensing measurements). Finally, one of the main systematics for the weak lensing will be determining the redshifts of background galaxies. Because of the matched field- of-views, MUSE will provide redshifts for a large fraction of the background galaxies.

GALDARK is organized in the form of 8 work packages addressing each of our main scientific questions:

- **WP1: Weak lensing of luminous red galaxies from BOSS, emission line galaxies from eBOSS, and photometric samples.** The goal of this work package is to measure galaxy-galaxy lensing using the HSC survey. These measurements will be divided into a series of different samples (redshift, stellar mass) and will be used as input for all three of our large-scale goals.

- **WP2: Clustering of luminous red galaxies from BOSS, emission line galaxies from eBOSS, and photometric samples.** The work-package is similar to WP1 but concerns clustering measurements.

- **WP3: Developing state-of-the-art semi-empirical models via N-body simulations.** Goals LS-A and LS-C will require theoretical modeling derived directly from N-body simulations. Our approach will be to populate N-body simulations with galaxy models and to compute the model predictions directly from the mocks. This approach will require significant computational resources (the purchase of a large cluster is requested in the budget).

- **WP4: Redshift estimators via clustering techniques.** To achieve goal LS-A, we will need to develop well-understood redshift estimators for the HSC survey. The goal of this work-package is to develop "clustering redshift" estimators (Menard et al. 2013, Rahman et al. 2014) and to apply these methods to the HSC survey.

- **WP5: Assessing systematics in the weak lensing analysis of galaxies in close pair configurations.** Measurements of small-scale weak lensing will require developing methods to measure galaxy shapes in close pair configurations. The goal of this work-package is to develop a suite of simulations to test shear and photoz recovery on these small scales using the GalSim simulation package (Mandelbaum et al. 2014).

- **WP6: Testing methods on full idealized mock observations of MaNGA galaxies.** The goal of this work package will be to use a suite of simulations to test methods for combining resolved kinematics with stacked weak lensing measurements. For this we will use a suite of fully idealized mock observations of MaNGA that are currently being developed within the MaNGA team.

- **WP7: Analysis of kinematics from MaNGA BCGs and HSC weak lensing.** The goal of this work package is to perform a joint analysis of the kinematics and lensing of our MaNGA BCG sample. MaNGA will provide resolved kinematics at 1-2 effective radii. Weak lensing from HSC will provide the shape of the density profile at larger radii (see Figure 3). By using a joint analysis of kinematics and weak lensing, we will be able to robustly determine dark matter fractions for BGCs.

- **WP8: HST and MUSE follow-up of most massive clusters.** The MaNGA program will be extended by proposing a follow-up survey of 50 BCGs in the most massive clusters at z=[0.1,0.2] with MUSE on the VLT and with the ACS camera on the Hubble Space Telescope. This work-package involves writing the proposals to secure this data set as well as the analysis of the joint analysis of the data set.

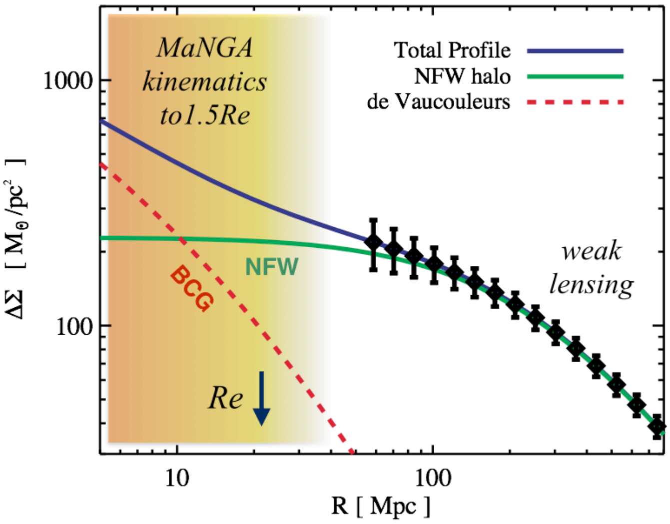

Figure 3. Predicted weak lensing signal for BCGs in our MaNGA sample with halo masses between $M_h=10^{14}$ $M_\odot$ and $M_h=10^{14.25}$ $M_\odot$ in the HSC survey. The blue curve shows the total mass profile, while the red and green curves show the stellar and dark matter profiles, respectively. Weak lensing measurements will enable us to accurately study the shapes of density profiles on large scales while our MaNGA ancillary program will constrain the mass profile at 1.5Re using resolved kinematics. Direct lensing measurements (not stacked) will be possible for BCGs in halos with $M_h>10^{14.5}$ $M_\odot$.

Team Composition and Budget

The GALDARK team will consist of the P.I, two post-doctoral scholars, and three PhD students. PhD and postdoctoral appointment will be three years each (a total of 18 FTE over 5 years). Post-doctoral scholars and three PhD will have complementary skill sets ranging from weak lensing and clustering measurement to working with N-body simulations. Each PhD student and post-doc will be a participating member in a large international collaboration and will benefit from direct access to the expertise of these collaborations.

The P.I will be fully involved in GALDARK and is covered at the 100% level over 5 years. Salaries are determined according to the CNRS salary scale: 89.7k€ per FTE for the P.I, 33k€ per FTE for PhD students and 50k€ per FTE for postdoctoral scholars. The total cost of salaries is **1048k€.** In addition, we request funding for travel (**70k€**), for hosting visitors and organizing a small invitation only workshop (**35k€**). Other costs include computer equipment (**24k€**), publications (**15k€**), and consumables (**3k€**). Because I will move from a non-EU country, I am eligible for additional start-up costs. As start-up costs, I request 200k€ to buy-in to the SDSS IV project and 100k€ for a modern cluster facility to support computational needs. The total budget before start-up costs is **1,494,856€** and the total budget including start-up costs is **1,819,856€.**

Impact of GALDARK and Future Prospects

This work, funded by an ERC grant, will enable GALDARK team members to push the current boundaries in this field with the ambitious goal of completing the galaxy-halo picture at redshifts below z=1. The impact of our work will be driven by a) exploiting synergies between new state-of-the art surveys, b) developing new observational techniques (particularly our small scale component), and b) the use of sophisticated modelling approaches. ***Our work will provide the most complete and holistic view of the link between galaxies and dark matter before the era of Euclid and WFIRST***. The methods and techniques developed via this ERC grant will be of tremendous value for the preparation and analysis of the Euclid survey in 2020. Finally, the techniques developed in GALDARK will naturally extend to next generation surveys such as Euclid and 4MOST (de Jong et al. 2012). ***A joint analysis of galaxy-galaxy lensing from Euclid with clustering from 4MOST (via the methods developed in GALDARK) and from NISP-S samples will provide an unparalleled view of the galaxy-dark matter connection.***

REFERENCES

de Jong R. S. et al., 2012, in Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, Vol. 8446, Society of Photo-Optical Instrumentation Engineers (SPIE) Conference Series, p. 0
Hudson M. J. et al., 2015, MNRAS, 447, 298
Kobayashi M., Leauthaud A., More S., Okabe N., Aigle C., Rhodes J., 2015, Monthly Notices of the Royal Astronomical Society, submitted
Leauthaud A. et al., 2015, MNRAS, 446, 1874
Leauthaud A., Tinker J., Behroozi P. S., Busha M. T., Wechsler R. H., 2011, ApJ, 738, 45
Leauthaud A. et al., 2012, ApJ, 744, 159
Leauthaud A., et al., 2007, ApJS, 172, 219
Mandelbaum R. et al., 2014, ApJS, 212, 5
Ménard B., Scranton R., Schmidt S., Morrison C., Jeong D., Budavari T., Rahman M., 2013, ArXiv e-prints
Newman A. B., Treu T., Ellis R. S., Sand D. J., 2013, ApJ, 765, 25
Rahman M., Ménard B., Scranton R., Schmidt S. J., Morrison C. B., 2014, ArXiv e-prints
Shankar F. et al., 2014, ApJ, 797, L27
Sonnenfeld A., Treu T., Marshall P. J., Suyu S. H., Gavazzi R., Auger M. W., Nipoti C., 2014, ArXiv e-prints
Velander M. et al., 2014, MNRAS, 437, 2111

Section b: Curriculum Vitae (max. 2 pages)

PERSONAL INFORMATION

LEAUTHAUD, Alexie

Date of birth: 15th September 1979

Nationality: French and Australian

URL for web site: http://member.ipmu.jp/alexie.leauthaud/

- **EDUCATION**

2004-2007	PhD in Astrophysics with honors (advisors Jean-Paul Kneib and Olivier Le Fevre) Laboratoire d'Astrophysiqe de Marseille (LAM), France
2003 - 2004	Master in Astrophysics Institut d'Astrophysque de Paris (IAP), Paris VI
2002	Master in Aeronautical and Space Engineering (ENSICA), Toulouse, France

- **CURRENT POSITION**

2013 – present	Assistant Professor Kavli Institute for the Physics and Mathematics of the Universe, U Tokyo, Japan

- **PREVIOUS POSITIONS**

2011 – 2013	Kavli IPMU distinguished post-doctoral fellowship Kavli Institute for the Physics and Mathematics of the Universe, U Tokyo, Japan
2007 – 2011	Chamberlain fellowship Lawrence Berkeley National Laboratory (LBNL), Berkeley, USA

- **FELLOWSHIPS AND AWARDS**

2011 – 2013	Kavli IPMU distinguished post-doctoral fellowship, U Tokyo, Japan
2007 - 2011	Chamberlain fellowship, LBNL, Berkeley, USA
2004	French National scholarship for graduate studies, France
2001	ENSICA scholarship to pursue a double degree, France

- **SUPERVISION AND MENTORING OF STUDENTS AND POSTDOCTORAL FELLOWS**

2013 – present	Claire Lackner, postdoctoral scholar, Kavli IPMU, Japan
2013 – present	Shun Saito, postdoctoral scholar, Kavli IPMU, Japan
2014 – present	Hanako Hoshino, graduate student, U Nagoya, Japan
2014 – present	Masato Kobayashi, graduate student, U Nagoya, Japan
2009 – 2011	Matt George, graduate student, Berkeley, USA
2010	Charlotte Welker, undergraduate student, ENS, Paris
2009	Melody Wolk, undergraduate student, ENS, Paris

- **TEACHING ACTIVITIES**

2006	Lecturer in Linear Algebra, University of Marseille Provence, France
2004 – 2005	Assistant mathematics teacher, University of Marseille Provence, France

- **ORGANISATION OF SCIENTIFIC MEETINGS**

2015 LOC, "*Getting a Grip on Galactic Girths"*, Kavli-IPMU, Tokyo
2014 SOC, *"Multi-wavelength Heritage of Stripe 82*", Princeton, USA
2013 Workshop organizer for the Aspen centre for physics, "*The Next Decade of Weak Lensing Science",* Aspen, USA
2013 LOC, "*Cosmological Information from Small Scales*", Kavli-IPMU, Tokyo
2012 SOC, "*Gravitational Lensing in the Age of Survey Science*", SnowPAC, USA
2012 Workshop organizer, "*Cosmological Information from Small Scales*", Stanford, USA

- **COMPETITIVELY OBTAINED FUNDING AND TELESCOPE TIME**

2014 Co.I, CREST grant, Japan Science and Technology Agent, 3 million €
2014 Co.I, MaNGA BCG ancillary program, 50 IFUs
2007-2010 Co.P.I, Decoding Dark Energy with Weak Gravitational Lensing, LBNL Laboratory Directed Research and Development grant (∼500k)
2010 P.I, The Brightest Cluster Galaxies in Stripe 82, Sloan-III ancillary proposal (2000 spectra)
2010 Co-P.I, CFHT/Megacam High-Resolution Imaging of the SDSS Stripe 82: Measuring the Mass Distribution of Structures from Clusters to Galaxy Scales, CFHT, 70h
2010-2011 Co.I, NIR (J and K) imaging on Stripe 82, CFHT and VISTA, ∼100h
2010 Co.I, The Dark Matter - AGN Connection and Weak Lensing, Chandra archive proposal
2009 Co.I, Probing the merging history of group halos and galaxies in groups since $z \sim 1$, VLT, 4 nights
2009 Co.I, Deep NIR spectroscopy of record-breaking cluster candidates at z=1.8, Subaru 3 nights
2005 Co.I, Studying strong gravitational lenses in COSMOS, VLT, 2 nights

- **COMMISSIONS OF TRUST**

2013 Reviewer, Subaru open use proposals
2012 – present Reviewer, Astrophysical Journal
2012 – present Reviewer, Monthly Notices of the Astrophysical Society
2010 Reviewer, European Research Council (ERC)

- **SCIENCE COMMUNICATION AND PUBLIC OUTREACH**

2012 Kavli-IPMU, host and lecture to female high-school students with interests in science.
2010 Public lecture, "*Dark energy: finding your way in the dark*", Lawrence Hall of Science
2009 Science at the theater, "*What science tells us about the hidden universe*", Berkeley Repertory
2009 Public lecture, "*What is gravitational lensing?",* LBNL Summer Lecture Series
2009 Public lecture, "*Gravitational Lensing and Cosmology*", East Bay Astronomical Society

- **MAJOR COLLABORATIONS**

  - The Cosmic Evolution Survey (COSMOS), PI: Nick Scoville (Caltech USA)
  - The Stripe 82 Canada France Hawaii Telescope Survey (CS82), PIs: Jean-Paul Kneib, Martin Makler, Ludovic van Waerbeke
  - The Hyper-Suprime Cam Survey (HSC), P.I: Satoshi Miyazaki

- **CAREER BREAKS**

2013 Maternity leave – 4 months

Appendix: All on-going and submitted grants and funding of the PI (Funding ID)
<u>*Mandatory information*</u> *(does not count towards page limits)*

On-going Grants

Project Title	*Funding source*	*Amount (Euros)*	*Period*	*Role of the PI*	*Relation to current ERC proposal*[2]
CREST Big-data in the HSC era	Japan Science and Technology Agency	3 million €	2014-2017	The P.I is Naoki Yoshida. I am a Co-I.	Only related to the current proposal in that this grant supports database development and visualization tools for the HSC survey (but this grant does not support any science analysis).

Grant applications

Project Title	*Funding source*	*Amount (Euros)*	*Period*	*Role of the PI*	*Relation to current ERC proposal*[2]
Gravitational lensing with HSC	Japan Society for the Promotion of Science	50,000€	2015-2018	PI	To support travel related to the HSC survey (grant not yet approved).

[2] Describe clearly any scientific overlap between your ERC application and the current research grant or on-going grant application.

Section c: Early achievements track-record (max. 2 pages)

During my PhD thesis I was one of the four key members of the COSMOS weak lensing team, which produced more than 20 weak lensing publications, including a cover article for the journal Nature. After my PhD I received a 5-year Chamberlain fellowship to the Lawrence Berkeley National Lab. After Berkeley, I received a second 5-year Fellowship from the Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU). In 2013 I was promoted to Assistant Professor and I am now leading a group of 2 PhD students and several post-doctoral scholars. My core expertise is measurements and theoretical interpretation of weak lensing. I am co-PI on the CS82 weak lensing survey which mapped out 150 deg^2 of the "Stripe 82" equatorial region for weak lensing studies. I have also played a leading role in realizing the HSC survey, including participating in writing the proposal that was awarded 300 nights on Subaru. I pioneered early work in the field of the galaxy-halo connection with two studies that have now become a leading reference in this domain (Leauthaud et al. 2011, 2012). My observational constraint on the stellar-to-halo mass relation (Leauthaud et al. 2012) was one of the top ten cited papers in Astrophysics in 2012.

1. Selected Publications in Refereed Journals

Total number of publications: **84**. H-index=**43**. Total number of citations= **6420** (excluding self-citations).
I have more than 20 publications without my thesis advisor. The symbol ⊙ marks publications without my thesis advisor. This list of selected publications list is ordered by year of publication.

⊙ ***[cite 0]* - Leauthaud, A.** et al. 2015, The Dark Matter Halos of Moderate Luminosity AGN as Determined by Weak Gravitational Lensing and Host Stellar Mass, MNRAS, 446, 1874-1888

• ***[cite 12]*** - Hand, N., **Leauthaud, A**., et al. 2015, First Measurement of the Cross-Correlation of CMB Lensing and Galaxy Lensing, Physical Review accepted, arXiv:1311.6200

⊙ ***[cite 15]*** - Reid, B. A., Seo, H.-J., **Leauthaud, A**., Tinker, J. L., & White, M. 2014, A 2.5 per cent measurement of the growth rate from small-scale redshift space clustering of SDSS-III CMASS galaxies, MNRAS, 444, 476

⊙ ***[cite 32]*** - Tinker, J. L., **Leauthaud, A.,** Bundy, K., George, M. R., Behroozi, P., Massey, R., Rhodes, J., & Wechsler, R. H. 2013, Evolution of the Stellar-to-dark Matter Relation: Separating Star-forming and Passive Galaxies from z = 1 to 0, ApJ, 778, 93

⊙ ***[cite 58]* - Leauthaud, A.** et al. 2012, The Integrated Stellar Content of Dark Matter Halos, ApJ, 746, 95

• ***[cite 165]* - Leauthaud, A.** et al. 2012, New Constraints on the Evolution of the Stellar-to-dark Matter Connection: A Combined Analysis of Galaxy-Galaxy Lensing, Clustering, and Stellar Mass Functions from z = 0.2 to z =1, ApJ, 744, 159

⊙ ***[cite 49]*** - George, M. R., **Leauthaud, A.,** et al. 2012, Galaxies in X-Ray Groups. II. A Weak Lensing Study of Halo Centering, ApJ, 757, 2

⊙ ***[cite 53]*** - Nipoti, C., Treu, T., **Leauthaud, A.,** Bundy, K., Newman, A. B., & Auger, M. W. 2012, Size and velocity-dispersion evolution of early-type galaxies in a Λ cold dark matter universe, MNRAS, 422, 1714

⊙ ***[cite 30]*** - Schmidt, F., **Leauthaud, A**., Massey, R., Rhodes, J., George, M. R., Koekemoer, A. M., Finoguenov, A., & Tanaka, M. 2012, A Detection of Weak-lensing Magnification Using Galaxy Sizes and Magnitudes, ApJ, 744, L22

⊙ ***[cite 29]*** - Mandelbaum,R., Hirata,C.M., **Leauthaud,A.,**Massey,R.J., Rhodes,J.2012, Precision simulation of ground-based lensing data using observations from space, MNRAS, 420, 1518

• ***[cite 55]*** - George, M. R., **Leauthaud, A**., et al. 2011, Galaxies in X-Ray Groups. I. Robust Membership Assignment and the Impact of Group Environments on Quenching, ApJ, 742, 125

⊙ ***[cite 50]* - Leauthaud, A**. Tinker, J., Behroozi, P. S., Busha, M. T., & Wechsler, R. H. 2011, A Theoretical Framework for Combining Techniques that Probe the Link Between Galaxies and Dark Matter, ApJ, 738, 45

⊙ ***[cite 21]*** - Rhodes, J., **Leauthaud, A.,** Stoughton, C., Massey, R., Dawson, K., Kolbe, W., & Roe, N. 2010, The Effects of Charge Transfer Inefficiency (CTI) on Galaxy Shape Measurements, PASP, 122, 439

• ***[cite 133]* - Leauthaud, A.,** et al. 2010, A Weak Lensing Study of X-ray Groups in the Cosmos Survey: Form and Evolution of the Mass-Luminosity Relation, ApJ, 709, 97

⊙ ***[cite 94]*** - Daniel, S. F., Linder, E. V., Smith, T. L., Caldwell, R. R., Cooray, A., **Leauthaud, A**., &

Lombriser, L. 2010, Testing general relativity with current cosmological data, PhRvD, 81, 123508

• ***[cite 160]*** - **Leauthaud, A.,** et al. 2007, Weak Gravitational Lensing with COSMOS: Galaxy Selection and Shape Measurements, ApJS, 172, 219

• ***[cite 190]*** - Massey, R., Rhodes, J., **Leauthaud, A.,** et al., 2007, COSMOS: Three-dimensional Weak Lensing and the Growth of Structure, ApJS, 172, 239

• ***[cite 183]*** - Massey, R., Rhodes, J., Ellis, R., Scoville, N., **Leauthaud, A.,** et al. , 2007, Dark matter maps reveal cosmic scaffolding, Nature, 445, 286

2. Student Publications

In 2012 I supervised Charlotte Welker (ENS) and this collaboration ultimately lead to one publication (Hand et al. 2015). In Berkeley, I also supervised Matt George (UCB) and this collaboration lead to three publications (George et al. 2011,2012, 2013). I am currently supervising two graduate students with two submitted publications:

⊙ Hoshino, H., **Leauthaud, A**., et al. 2015, Luminous Red Galaxies in Clusters: Central Occupation, Spatial Distributions, and Mis-Centering, MNRAS submitted

⊙ Kobayashi, M., **Leauthaud, A**., et al. 2015, Can we Use Weak Lensing to Measure Total Mass Profiles on 20 kpc Scales?, MNRAS submitted

2. Invited Conference Presentations

I am been invited to give a number of invited talks in major international conferences. Here I list my upcoming talks in 2015 as well as my recent invited talks from 2014.

Upcoming contributions:

- June 2015, Invited talk, *Let's group: the life cycle of galaxies in their favorite environment*, The Excellence Cluster Universe, Munich
- July 2015, Invited talk, *Theoretical and Observational Progress on Large-Scale Structure in the Universe*, MPA/ESO/MPE/Excellence Cluster Universe Joint Conference

Recent contributions in 2014:

- July 2014, Invited talk, *Galaxy Masses as Constraints of Formation Models*, IAU symposium, Oxford
- March 2014, Invited talk, *The Multi-wavelength Heritage of Stripe 82*, Princeton

3. Selected List of Recent Colloquia and Seminars

I have also given a number of invited departmental seminars and colloquia. Here I list only a selected sub-set of recent talks.

- University of Santa-Barbara, Seminar, 2014
- Aspen Center for Physics, Colloquium, 2014
- Princeton, Colloquium, 2014
- Institut d'Astrophysique de Paris (IAP), Colloquium, 2014

(2013: maternity leave and limited travel)

- U.Tokyo, Astronomy Dept. Colloquium, 2012
- ROE Edinburgh Colloquium, 2012
- ICG Portsmouth Colloquium, 2012

3. Selected List of Recent Colloquia and Seminars

Finally, I have also organized a number of international meetings and workshops (see resume for further details).