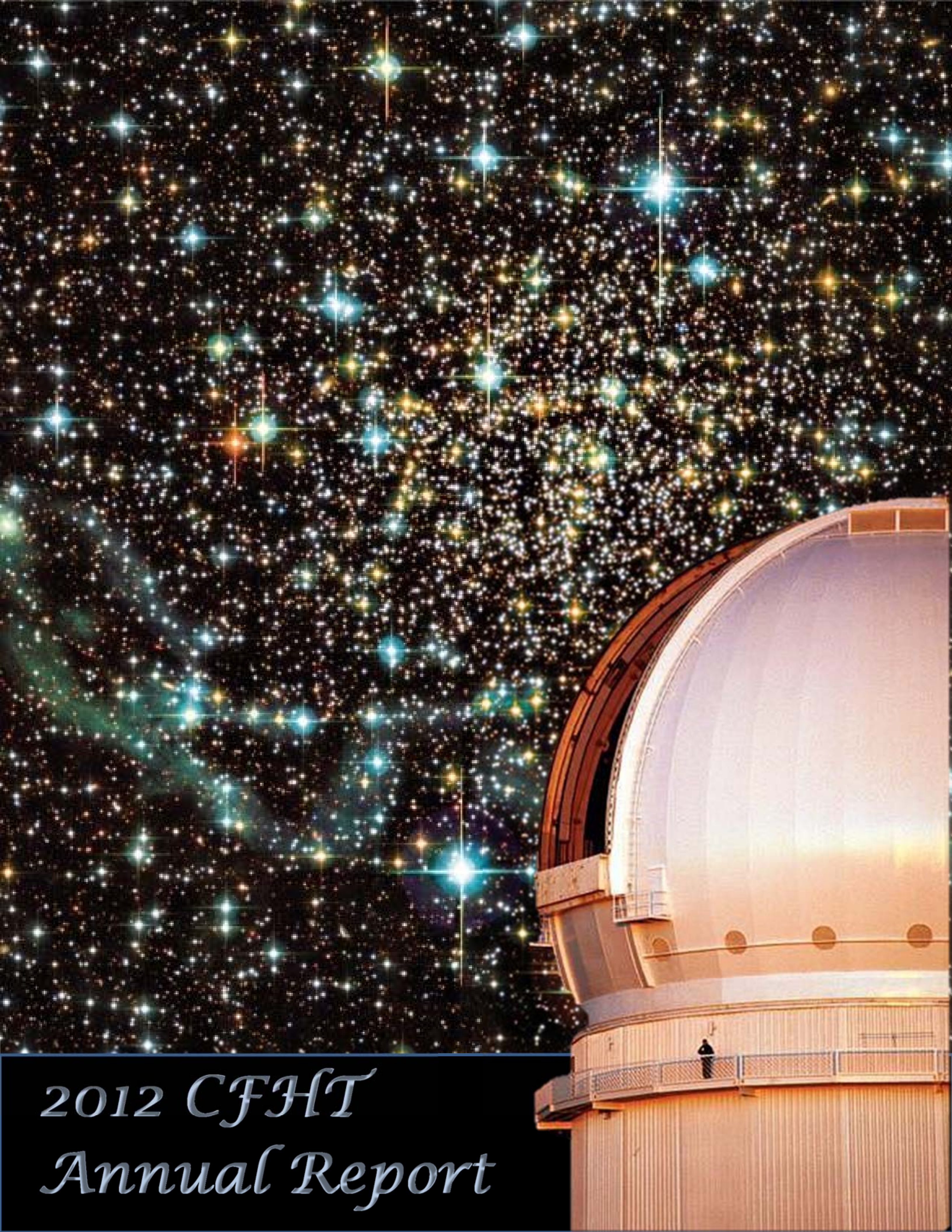

2012 CFHT Annual Report

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Front and back covers: A sunset image of CFHT superimposed on an image of NGC 6791, recorded by CFHT.

Director's Message

From 1990 to 1994 I was the UH sponsored Resident Astronomer at CFHT. In late spring of 1994, while on the summit and with my eyes glued to a computer monitor in search of faint signal in a Redeye frame, Jean-Pierre Maillard leaned over my right shoulder and said quietly "you're going to miss this". His comment took me by surprise and for some reason stuck with me all these years. A couple months later I started work at Gemini and today, his words seem strangely prophetic as I (re)start my career at CFHT, this time as the new Director. Jean-Pierre and I had worked for years developing the world's first imaging FTS system in astronomy. Though it was cumbersome to operate and the technology crude compared to what is being used now to craft SITELLE, CFHT's first facility-class imaging FTS, the seeds of my future at CFHT were planted decades ago through instruments named FTS, Redeye, and Bear and people named Monet, Davidge, Rigaut, LeFevre, Bohlender, Couturier, Kerr, Bryson, Salmon, and many others. The CFHT that I found on 1 May 2012, my first day back at a familiar "home", was concurrently similar and different from what I remembered. Like two friends who have strayed apart for decades and are reunited after separate voyages, we have both grown over time, learning much along the path of life, and have much to offer each other as we now walk a common path ahead. It is with this history in mind that I welcome the readers of CFHT's 2012 Annual Report to learn about the challenges and triumphs of 2012, and exciting possibilities about CFHT's future.

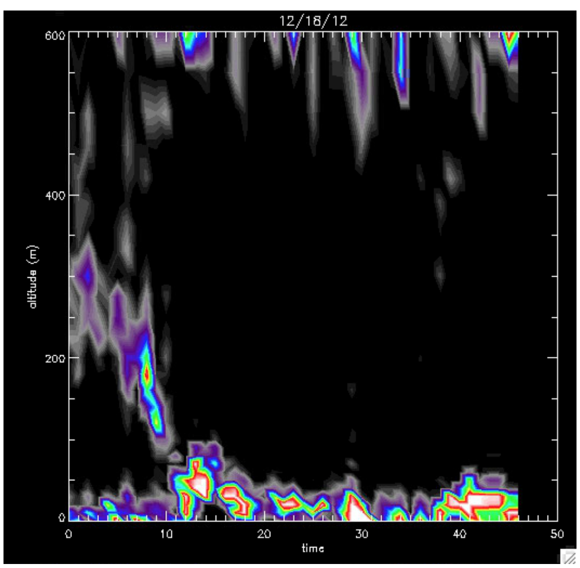
Images from the past and future. Above: a 2.2 µm image of the team that built CFHT's first facility infrared cameras over 20 years ago. Below: a CAD rendering of CFHT's next facility instrument, SITELLE, featuring modern materials and control technologies that were unobtainable 20 years ago and will help revolutionize integral field spectroscopy at CFHT.

In the pages that follow, activity in the areas of science, engineering, administration, and outreach are summarized. Of course capturing the events of an entire year in a single report is challenging but what we have included will hopefully give the reader a good understanding of events at CFHT in 2012. Much of my attention since returning to CFHT has been invested in exploring opportunities to enhance CFHT's future. I sometimes refer to the "pillars" of CFHT's strategic plans as (1) developing new capabilities, (2) expanding the partnership, and (3) transforming the facility. These elements of our strategic plans are interwoven as they collectively represent near-term projects to complete (e.g., dome venting and new instruments) and long-term options to explore (e.g., ngCFHT). This approach builds off the many years of successful development and operations at CFHT, the already expanding partnership through our Associate Partners in Asia and Brazil, and is intended to advance CFHT in the broader context of facilities across Mauna Kea. Opportunities for collaborative operations and development are being explored that do more than just sustain basic capabilities for reduced costs. They are intended to provide the CFHT community with research opportunities that would otherwise be impossible. Some of the most visible aspects of this effort in 2012 occurred in the form of 3 receptions that CFHT hosted, two in Amsterdam at the SPIE Astronomical Instrumentation Conference, and one in Beijing at the IAU General Assembly. These meetings gave our Associate Partners in particular an opportunity to explore possibilities in future development activity at CFHT and discuss with senior members of CFHT's staff ideas for better collaboration in the future.

By far the most pressing matter at "ground zero" for the CFHT staff during 2012 was the loss of a functioning dome shutter for 67 days. Details of the incident can be found in the Engineering Report. This was the longest unplanned shutdown for CFHT in its ~35 year history and required a Herculean effort across essentially the entire staff, consultants, and contractors to recover from. The reasons for the shutter failure are numerous and complex but collectively signal the challenges of operating an aging facility that has functioned under harsh conditions on the summit of Mauna Kea for decades. It forced us to reconsider our preventative maintenance program and was an enormous perturbation on regular operations. Nonetheless, in the end the lengthy recovery process will leave in place a dome shutter that is better understood and functioning more robustly than perhaps it has over its entire lifetime.

Considerable effort was also made in the further development of the IMAKA project, SPIRou, and SITELLE. Though the future of IMAKA and SPIRou remain uncertain, due in large part to funding challenges, SITELLE remains on-track for delivery in 2013. The bulk of the effort with IMAKA Phase A in 2012 was dedicated to high resolution low-altitude seeing measurements using a multi-wavefront sensor (mWFS) system at the UH 88" and CFHT in multi-night campaigns that generated many terabytes of data. This was intended to validate the feasibility of achieving GLAO performance across a field as large as 1 deg, as envisioned by the IMAKA team. SPIRou advanced to the PDR phase but, after considerable discussions by the PDR review panel, SAC, and Board, further development of the instrument will only occur as a Guest Instrument as additional sources of funding to build SPIRou are sought.

On a more distant horizon, work was also completed on several fronts with developing the ngCFHT concept, including technical feasibility studies and science case development led by staff at NRC-Herzberg, in collaboration with commercial firms and astronomers scattered around the globe. Initial planning for the ngCFHT Workshop in Hilo, Hawaii during 2013 was also completed. Combined with the CFHT Triennial Users' Meeting, these key 2013 community-wide meetings will play an important part in developing a community consensus on the future of CFHT.



An example of some of the multi-wavefront sensor (mWFS) measurements made as part of the IMAKA development program in 2012 is shown. This shows the time evolution of turbulence along the line-of-sight for the instrument during measurements at CFHT. The dominance of low-altitude turbulence is striking.
Image courtesy Olivier Lai, Subaru/Gemini

Finally, take particular note of the wonderful science accomplishments summarized in the Science Report. Perhaps the most notable accomplishment was the final release (T0007) of the CFHT Legacy Survey – an enormous accomplishment spanning a decade of effort yielding multi-color photometry of millions of galaxies that will underpin research for many years to come. Other science highlights include observations of a rare super-luminous supernova, considerable progress in mapping dark matter at various scales (including in 3D), and observations of "extremes" in nature including a free-floating planet, an extremely small globular cluster, and the strongest magnetic field ever detected in a star. Enjoy!

Science Report

CFHTLS T0007 Data Release

The CFHT Legacy Survey team released the final version of the processed data of the survey. The release dubbed T0007 was made available to the world on 26 October 2012. The CFHTLS is a unique and powerful multi-color collection of data obtained over 6 years from the summit of Mauna Kea.

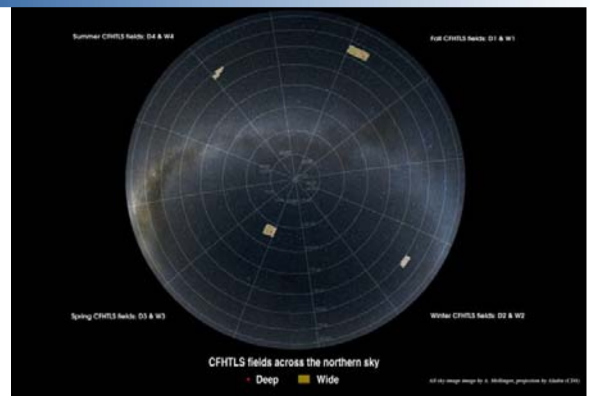


Figure 1 - The CFHTLS fields across the northern sky. The footprint of the four Deep and the four Wide fields from the CFHTLS projected on the entire northern sky observable from Mauna Kea (latitude +20) are shown. The spherical projection from the celestial pole appears to squash the Wide fields at lower latitudes. To be able to continuously collect data throughout the years, four fields in four opposite directions in the sky were selected. In two seasonal cases, the deep field overlaps with the wide field. Notice how the galactic plane from our Galaxy, the Milky Way, was avoided in order to probe into the deep universe.
Credit: CFHT/Terapix/CDS

The survey, performed with MegaCam, probes an extremely large volume of the universe, and includes tens of millions of galaxies, some as far as 9 billion light-years away. It provides a treasure trove for many years of astronomical research. This remarkable collection of data is a landmark achievement for CFHT and will help ground research in cosmology for many years.

The Legacy Survey observations began in 2003 and ended in 2009. Three more years were needed to accurately calibrate the huge volume of high-quality and homogeneous data obtained in five color-bands covering the optical domain from blue to red, including near-ultraviolet and near-infrared. The data revealed some 38 million objects, mostly very distant galaxies in various stages of evolution, across a combined area of sky totaling 155 square degrees, more than 800 times the surface area of the full moon.

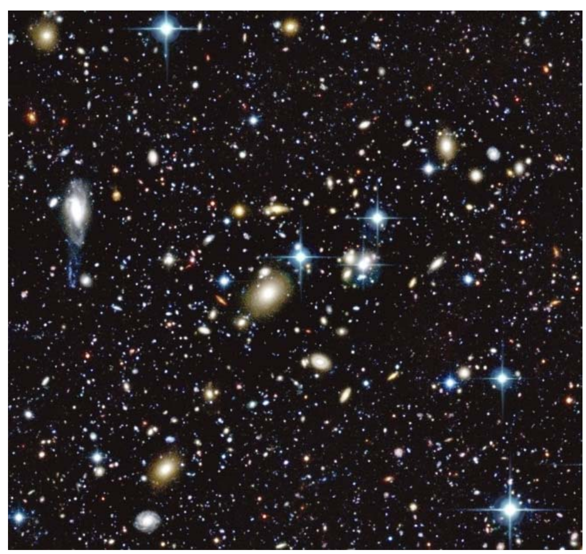


Figure 2 - This tiny fraction of a CFHTLS Deep field reveals a wallpaper pattern of galaxies. At least a thousand distant galaxies can be identified on this image. The entire CFHTLS revealed tens of millions of galaxies like these.

The CFHTLS provides high scientific return. The website (www.cfht.hawaii.edu/Science/CFHTLS/) presents an up-to-date list of more than 100 publications based, at least in part, upon CFHTLS data. Approximately 2/3 of all MegaCam publications over the 2007-2011 period involve CFHTLS data. The Legacy Survey has not only produced the most journal citations in the history of the Observatory, but CFHT's scientific impact, as reflected in published research, now ranks among the top 10 most productive telescopes in the world. This accomplishment reflects the enormous effort made across the entire CFHT community to support this remarkable survey, and bodes well for the scientific productivity of future major CFHT surveys. For more information, see the CFHTLS press release available through our website.

New Frontiers of Dark Matter

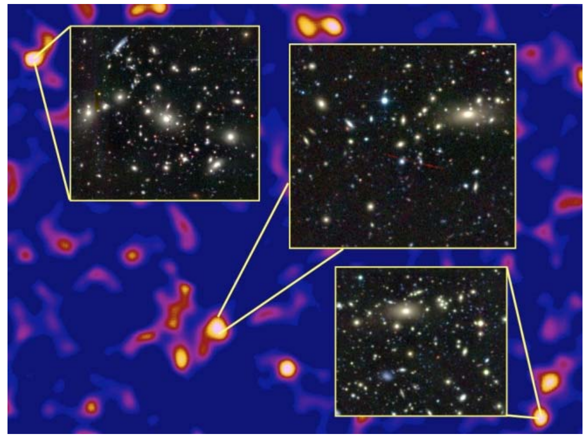


Figure 3 - CFHTLenS observations show that dark matter in the universe is distributed as a network of gigantic dense (light) and empty (dark) regions, where the largest dense regions are about the size of several Earth moons projected on the sky. The densest regions of the dark matter cosmic web host massive clusters of galaxies. Credit: Van Waerbeke, Heymans, and CFHTLenS collaboration.

The CFHTLS provides a rich dataset for scientists to exploit for many years. This year, archival images from the Legacy Survey were used to map, for the first time, dark matter on the largest scale ever observed. The team included researchers from the University of Victoria and the University of Edinburgh. They achieved their results by analysing images of about 10 million galaxies in four different regions of the sky. They studied the distortion of the light emitted from these galaxies, which is deflected as it passes massive clumps of dark matter during its journey to earth. Their project, known as the Canada-France-Hawaii Telescope Lensing Survey (www.cfhtlens.org), is a wonderful example of research enabled by CFHTLS.

Galaxies included in the survey are typically six billion light years away, meaning light captured by the telescope was emitted when the universe was approximately half its current age. The team's result has been suspected for a long time from studies based on computer simulations, but was difficult to verify due to the invisible nature of dark matter. This is among the first detections of dark matter on scales large enough to show the cosmic web in many directions.

Cosmic Explosions in the Early universe

The CFHTLS was design to find supernovae in order to characterize the properties of Dark Energy. However, the data also enable observations of supernovae in the early universe. Using a unique search technique, astronomers from the University of Technology in Australia, the University of Oxford in the UK, the Weizmann Institute of Science in Israel, the University of California Irvine and San Diego State University in the United States, the University of Toronto and the Université de Montréal in Canada found two "super-luminous" supernovae — stellar explosions 10–100 times brighter than other supernova types — in the very distant universe. Their results, which were reported on-line in Nature (www.nature.com/nature/journal/v491/n7423/full/nature11521.html), sets a record for the most distant super-luminous supernovae detected and offers the possibility of observing the explosions of the first stars to form after the Big Bang.

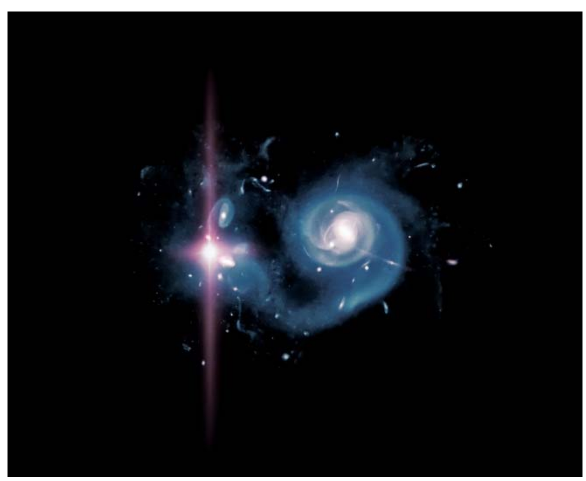


Figure 4 - High-resolution simulation of a galaxy hosting a super-luminous supernova and its chaotic environment in the early universe. Credit: Adrian Malec and Marie Martig (Swinburne University).

Super-luminous supernovae were discovered only a few years ago, and are rare in the nearby universe. Their origins are not well understood, but a small subset of supernovae are thought to occur when extremely massive stars undergo a nuclear explosion triggered by the conversion of high-energy photons into electron–positron pairs. Such events are expected to have occurred more frequently in the early universe, when massive stars were more common. This, and the extreme brightness of these events, encouraged the team to search for super-luminous supernovae at redshifts >2. They searched through a large volume of the universe through the CFHTLS images and found two super-luminous supernovae, at redshifts of 2.05 and 3.90 — breaking the previous "normal" supernova redshift record of 2.36, and implying that the production rate of super-luminous supernovae at these redshifts may be about 10 times higher than in the nearby universe.

In Abell 520, Dark Matter Core Defies Explanation

Abell 520 is a galaxy cluster located 2.4 billion ly away that, given its unusual structure, is nicknamed the Train Wreck Cluster. Looking at the distribution of this cluster's luminosity, mass and hot gas using CFHT MegaCam, HST WFPC2 and NASA's Chandra observatory, a team of astronomers from the University of Victoria found that the dark matter appears to have collected into a "dark core" while most of the galaxies seemed to have moved on, sailing past the collision site.

This result could present a challenge to basic theories of dark matter, which predict that galaxies should be anchored to the invisible substance, even during the shock of a collision. One way to study dark matter is by analyzing collisions between galaxy clusters, the largest structures in the universe. When galaxy clusters collide, astronomers expect galaxies to be bound to the dark matter. Clouds of intergalactic gas, however, plow into one another, slow down, and lag behind the impact. That theory was supported by visible-light and X-ray observations of a colossal collision between two galaxy clusters called the Bullet Cluster. The galactic grouping has become a textbook example of how dark matter should behave. But studies of Abell 520 showed that dark matter's behavior may not be so simple. The original observations found that the system's core was rich in dark matter and hot gas but contained no luminous galaxies, which normally would be seen in the same location as the dark matter. NASA's Chandra X-ray Observatory detected the hot gas. Astronomers used the Canada-France-Hawaii and Subaru telescopes to infer the location of dark matter by measuring how it bends light from more distant background galaxies through gravitational lensing.

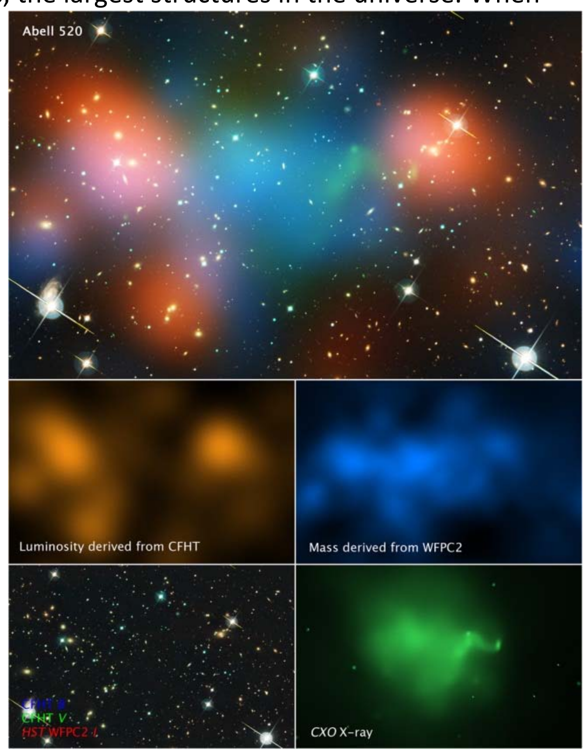


Figure 5 – Image Credit: NASA, ESA, CFHT, CXO, M. J. Jee (University of California, Davis), and A. Mahdavi (San Francisco State University, California)

The image on top of Figure 5, which is a composite of the four images shown below it, illustrates the distribution of dark matter, galaxies, and hot gas in the core of the merging galaxy cluster Abell 520, which formed from a violent collision of massive galaxy clusters. The orange colored picture shows the starlight from galaxies, derived from observations by the Canada-France-Hawaii Telescope. The blue colored picture pinpoints the location of most of the mass in the cluster, which is dominated by dark matter. The dark-matter map was derived from the Hubble Wide Field Planetary Camera 2 observations by detecting how light from objects behind the cluster is distorted by the material in the cluster. The green-tinted image in Figure 5 shows regions of hot gas, as detected by NASA's Chandra X-ray Observatory. This hot gas component is evidence that a collision took place.

The natural-color image of the galaxies was taken with NASA's Hubble Space Telescope and with the Canada-France-Hawaii Telescope. The blend of blue and green in the center of the image reveals that a clump of dark matter resides near most of the hot gas, where very few galaxies are found. This finding confirms previous observations of a dark-matter core in the cluster. The result could present a challenge to basic theories of dark matter, which predict that galaxies should be anchored to dark matter, even during the shock of a collision.

Dark Matter Filaments Studied in 3D for the First Time

An international team of astronomers from France, the United States, Japan, Denmark, and the UK used the NASA/ESA Hubble Space Telescope in concert with telescopes at the summit of Mauna Kea to study a giant filament of dark matter in 3D for the first time. Extending 60 million light-years from one of the most massive galaxy clusters known, the filament is part of the cosmic web that constitutes the large-scale structure of the universe, and is a leftover of the very first moments after the Big Bang. If the high mass measured for the filament is representative of the rest of the universe, then these structures may contain more than half of all the mass in the universe. The team combined high resolution images of the region around the massive galaxy cluster MACS J0717.5+3745 (or MACS J0717 for short), taken using Hubble, NAOJ's Subaru Telescope and the Canada-France-Hawaii Telescope. Spectroscopic data on the galaxies was acquired by the W. M. Keck Observatory and the Gemini Observatory. Analysing these observations together gives a complete view of the shape of the filament as it extends out from the galaxy cluster almost along our line of sight. A truly collaborative effort!

Figure 6 - This illustration shows HST's image of MACS J0717 overlaid with the location of the cluster and filament's mass (in blue).

Very Faint Cluster Orbiting the Milky Way

A team of American, Canadian and Chilean astronomers stumbled onto a remarkably faint cluster of stars orbiting the Milky Way that puts out as much light as only 120 modest Sun-like stars – orders of magnitude smaller than typical globular clusters. The tiny cluster, called Muñoz 1, was discovered near a dwarf galaxy in a survey of satellites around the Milky Way using CFHT's MegaCam and confirmed using the Keck II telescope. Muñoz 1's discovery was the result of a survey done with MegaCam in 2009 and 2010.

Strongest Magnetic Field in a Star Ever Measured

A group of Canadian and US based astronomers used the Hobby-Eberly Telescope (HET) at the University of Texas at Austin's McDonald Observatory and CFHT to measure the most magnetic massive star ever detected. To measure the strength of star's magnetic field, the team used ESPaDOnS at CFHT to measure small biases in the direction of rotation of the electromagnetic waves absorbed or emitted by atoms located in the star's magnetic field. They determined that the star's magnetic field is 20,000 times stronger

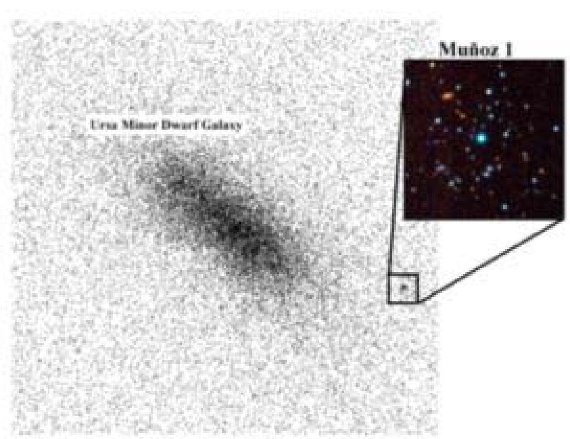


Figure 7 - The globular cluster Muñoz1 next to the Ursa Minor Dwarf Galaxy is shown.

than the Sun's, and almost 10 times stronger than that detected around any other high-mass star. At about 35 times the Sun's mass, the O-type star NGC 1624-2 lies in the open star cluster NGC 1624, about 20,000 light-years away in the constellation Perseus. This star is an extreme case-study which helps astronomers better understand all massive stars, which play an important role in the evolution of galaxies. When stars explode as supernovae, the heavy chemical elements born in their cores are scattered into space. Additionally, despite their short lives (NGC 1624-2 will live only about five million years, or one-tenth of one percent of the Sun's current age at mid-life), massive stars shape the galaxies in which they live. The magnetic field of a star can strongly influence its longevity and evolution. Because stellar magnetic fields at such extreme levels are poorly understood, models of stellar evolution are incomplete, but through observations like those made at CFHT are becoming more sophisticated.

Wandering Planet

Astronomers from France and Canada used ESO's Very Large Telescope and the CFHT to identify a body that is very probably a planet wandering through space without a parent star. This unusual free-floating planet candidate is the closest such object to the Solar System yet discovered at a distance of about 100 light-years. Its proximity, and the absence of a bright star very close to it, has allowed the team to study its atmosphere in great detail. This object also gives astronomers a preview of the exoplanets that future instruments aim to image around stars other than the Sun. Free-floating objects like CFBDSIR2149 are thought to form either as normal planets that have been booted out of their home systems, or as lone objects like the smallest stars or brown dwarfs. In either case these objects are intriguing. These free-floating planets could be common - perhaps as numerous as normal stars. If CFBDSIR2149 is not associated with the nearby AB Doradus Moving Group it is trickier to be sure of its nature and properties, and it may instead be characterized as a small brown dwarf. Both scenarios represent important clues about how planets and stars form and behave.

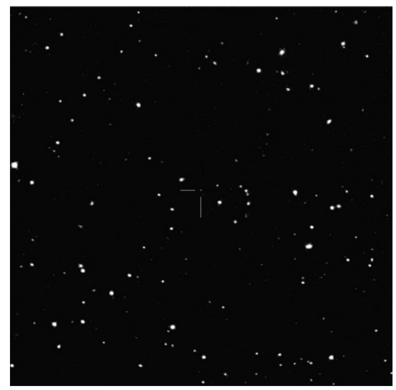


Figure 8 - WIRCam discovery image of CFBDSIR2149.
Credit: CFHT-Phillipe Delorme.

Jupiter's Smallest Moons

At only 2 kilometers in diameter, the smallest of two moons recently discovered orbiting Jupiter may be the giant planet's smallest known satellite. In September of 2010, two previously unknown distant satellites of Jupiter were discovered during routine observations of already known moons. These discoveries were then re-observed several times during the fall, in order to determine that they were indeed satellites of Jupiter, leading to their designations S/2010 J 1 and S/2010 J 2. With Jupiter now having 67 known satellites, the discovery of two tiny satellites does not have a large bearing on our understanding of the system but gives a more complete understanding of the low-mass regime of Trojan satellites. A paper by Alexandersen et al. (AJ, 144, 2012, 21A) details the discovery and tracking of these two moons. S/2010 J 1 was discovered on images taken at the Palomar 200 inch Hale Telescope on the 7th and 8th of September 2010, by an international team from NASA's Jet Propulsion Laboratory and the University of British Columbia.

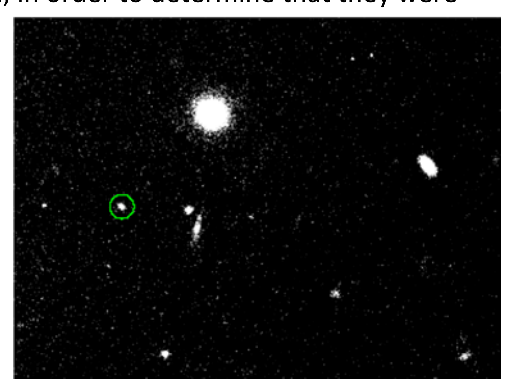


Figure 9 - CFHT image of S/2010 J 1 on the 8th of September 2010 (inside green circle).

Engineering Report

Dome Shutter

CFHT suffered the longest unplanned shutdown (67 days) in its 30+ year history due to a cascade of shutter drive unit failures that crippled the shutter and prevented any observations from being conducted. The recovery strategy, which spanned much of the year and continues in 2013 was to first regain nightly operations as soon as possible while not sacrificing safety, using a two-step approach that left the shutter operational again but still in need of considerable work to ensure continued safe operation. An extensive effort was launched to ascertain exactly what led to this drive system failure, including metallurgy analysis of sheered drive shafts, the use of a high rigger contracted from Honolulu to assist in the inspection of all rack tooth profiles, an end-to-end analysis of the control system, the use of miniature high-def cameras to record the precise interactions of the drive pinions with the gear racks, detailed assessments of the drive currents applied to each of the drive units, and even flying in one of the original engineers (Art “Charlie” Brown) to recount undocumented details in the system when constructed in the late ‘70’s. Essentially the entire staff helped with the initial recovery, including the identification and examination of decades-old drawings and maintenance logs to reconstruct the history of the system and identify clues as to why it failed now. Three of the enormous drive units (weighing thousands of pounds each) showing evidence of physical damage were systematically removed from the underside of the dome, transported to Waimea for inspection, then sent to Hilo Iron Works for repair, then back to the summit for reinstallation and testing. By the end of 2012 a combination of 7 (out of 8) drive units were being used to operate nightly of which 5 have been upgraded with new speed reducers. The system has enough performance margin to function safely this way, but all 8 units will be back in service with new reducers when all repairs are completed.

Figure 10 - A shutter drive unit showing, from left to right, the pinion roller assembly, the 319:1 speed reducer, the red steel unit frame, the brake and 5 hp drive motor.

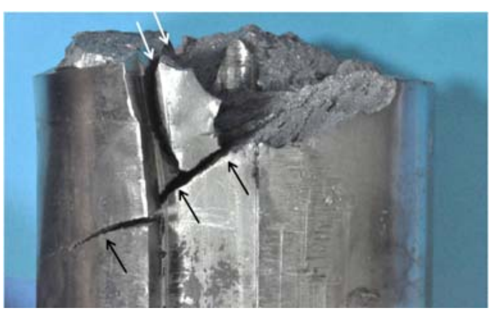


Figure 11 – This image was extracted from the metallurgy analysis of the ~4” solid steel drive shaft that was sheared in the shutter drive unit that failed in April 2012. This is an indication of the enormous forces at work in the drive system, and the “industrial grade” magnitude of the job to repair it.

It is important to note that this problem was not linked to the operation of the telescope from Waimea. The same e-stop that was pressed in Waimea in response to loud noises relayed by the dome microphones to the remote operator would have been hit from the summit, had the observer been stationed there instead. Likewise, the same immediate recovery procedure, which was to halt observations and leave the telescope in a safe state (albeit with the dome stuck open) while an engineering crew was deployed to inspect the situation on the summit, would have been used regardless of where the nighttime operations were being conducted. If anything, the telemetry from the shutter drives that was enabled by the remote operations program were a crucial component in the recovery process and will be used in the future to predict problems with individual drive units long before they catastrophically fail.

The drive unit failure in one case resulted from a crack in a speed reducer casing that was underspecified for its loads, while the remaining failures – one a catastrophic shearing of a reducer drive shaft – were traced to bending of the drive shaft, which in the single case sited above led to jamming of the drive against its rack gear teeth. The underlying cause of the shaft bending, which in two cases had existed for several years, is unclear, but is likely a result of a combination of events including the 2006 earthquake, changes to the control system in the mid-1990s that exacerbated issues related to poor load sharing between drives, and very small design margins and operating clearances in the drive units and in the shutter roller/rack geometries. Diagnosis and recovery from these events has been particularly difficult due to the weight and limited access to many of the shutter components.

Dome Venting Project

Contract negotiations were completed and the contract for vent unit design, fabrication and installation was signed in early December, 2012. Prior to signing the contract, at the request of the Office of Mauna Kea Management (OMKM) we re-submitted our proposal to OMKM together with a document showing compliance with the Mauna Kea Comprehensive Management Plan (CMP). Project approval was received from the MKMB after review by the Kahu ku Mauna Council and from the State Department of Land and Natural Resources. In response to the dome shutter problems, the contractors agreed to a 6 month project delay which now calls for installation of a single prototype vent unit in April, 2013, with the remaining 11 units to be installed in September, 2013. The preliminary and final design reviews were completed successfully in December, 2012 and acceptance testing of the prototype unit in Tucson is scheduled for March, 2013. When the prototype is installed we only plan to verify its basic operation and identify installation issues that will be of use in the installation of the subsequent 11 units. When all 12 vents are installed an extensive vent commissioning process will be launched to measure the impact of these vents on delivered image quality and optimize their settings as a function of ambient conditions. In tandem with the hardware contract, the CFHT vent control working group has been meeting regularly to design and implement the vent control system and to establish high-level control protocols that will be available to the observers.

Figure 12 - A rendering showing how four of the twelve vent units and their associated ice deflectors, rollup weather doors and internal louver vanes will look after installed in 2013.

SPIRou

A May 2012 SPIRou team meeting in Montreal was held to determine if the project would be ready for PDR in October. There was broad consensus that, though much work remained, the project would be ready. Accordingly the PDR was set for October 17-18 in Waimea and was chaired by John Rayner, also the CoDR chair, who was selected to ensure continuity across these important reviews and his considerable skills in infrared spectroscopy.

A critical trade between cost and performance became clear during the May meeting. The SPIRou science team reported the preliminary results of a mock survey to estimate the number and nature of exoplanets that might be detected in a ~300 night campaign of SPIRou on CFHT, using exoplanet frequency and orbital properties based upon the most recent literature (e.g., Kepler and HARPS results). Some of the key findings of this study include –

- SPIRou on CFHT would find about 1 exoplanet for each night allocated to the survey
- A significant number of these planets (several dozen) will be in the habitable zones of their host stars
- In order to reach this detection rate, SPIRou must reach a 1 m/s level of velocity sensitivity

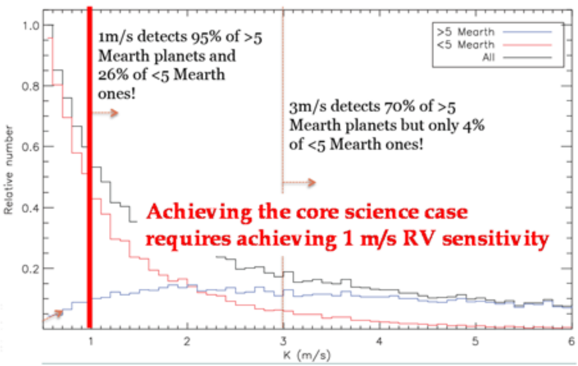


Figure 13 - A histogram of exo-planet detections made from Monte-Carlo simulations of a comprehensive SPIRou survey of nearby low mass stars.

Though always envisioned to achieve this level of sensitivity, the rapid rise in planet detections as a function of RV sensitivity is striking – achieving only 2-3 m/s sensitivity dramatically reduces the detection rate. In practice, given how hard it is to reach 1 m/s, this meant SPIRou would need to rely upon a robust design and several key technologies to achieve its core science objective – challenges that in general are not consistent with a highly cost constrained instrument. The projected shortfall, combined with the importance of reaching the 1 m/s velocity sensitivity and aforementioned grating challenges, were all subjects of scrutiny during the PDR.

In response to the PDR panel report and discussions with the CFHT executive, SAC, in its November, 2012 meeting recommended that SPIRou development not proceed past PDR with CFHT funding and resources. Although the SAC considered the SPIRou science case to be very strong and potentially world leading if the full K-band, polarimetric, 1 m/s precision were to be achieved in a timely fashion, overall the SAC was concerned with the outcome of the PDR review and in general echoed the concerns of the PDR review panel. Finally, the CFHT Board expressed its concern about the time needed to build the instrument and complete an exo-planet survey requiring nearly a decade. Combined with the need for 100% of CFHT's development funds for 5-6 years, the combination of risks was deemed unacceptably high to proceed with the instrument hence the decision to proceed only if external funds can be identified as a Guest Instrument.

SITELLE

The SITELLE CDR was held in Quebec June 27-28, 2012. Hosted by ABB, the company building SITELLE, a comprehensive review of the technical status of the instrument was conducted, with considerable time taken to discuss the coordination of development activity between CFHT, the University of Laval, and ABB over the next year, while the instrument goes through final integration and tests before delivery to CFHT in 2013. Perhaps the most important near-term milestone to achieve was the successful manufacture of the beamsplitter in the interferometer. Zygo was selected to make this crucial component. The first test coating on a witness sample was made in July. Coating of the precision substrates needed by SITELLE and then optically contacting them to create the final beamsplitter was completed successfully in December. This is an exceptionally difficult optical component to manufacture (arguably the most challenging part of the instrument) as the quality of the coatings and the reflected and transmitted wavefronts affect everything from the modulation efficiency of the system to the throughput at all wavelengths. ABB's design of the metrology system that will be used to control the scanning mirror in SITELLE appears sound and is predicated upon years of experience gained building similar FTS's in various commercial applications. It is based upon a commercial laser diode fiber fed illumination system that operates the scanning mirror closed loop using a 10 KHz sample rate and a set of PZT actuators to precisely control the position of the scanning mirror to an estimated 1/1000 wave accuracy under all instrument orientations. Unfortunately a design problem in the CCDs ordered for SITELLE led to a delay in the CCD delivery until April 2013. This represents a >6 month slip and complicates matters at CFHT, where the detector systems for SITELLE are being built. To help offset the delayed science detectors, CFHT is using engineering grade detectors on hand that are immediately available to integrate and test the detector system. The science grade CCDs, which will have improved red response over those originally ordered, will be installed in April 2013 after their arrival in Waimea with delivery of the entire detector system to Laval shortly thereafter. By the end of 2012, CFHT had designed, fabricated and assembled all the CCD dewar and controller components and had started their operational verification.

Figure 14 - The main SITELLE instrument structure during assembly at ABB. The truss members are stiff, light weight carbon fiber tubes.

Figure 15 – A fully assembled SITELLE science detector dewar is shown undergoing vacuum testing.

Overall we are impressed by the team at Laval/ABB and encouraged by the energy, enthusiasm, and engineering rigor being used to design and build SITELLE. The use of "non-traditional" materials including carbon fiber, 3D printed components, and PZT actuated metrology systems to achieve a lightweight, ultra-stiff design, is fairly new to astronomical instrumentation, as is, of course, the use of a Michelson interferometer to build a wide/integral field spectrometer. If SITELLE works as predicted, this instrument will likely get a lot of attention due to its elegant design (no fibers, slits, or lenslets), optical efficiency, and ability to achieve high spectral resolution over fields that, using "conventional" IFU technologies, would be prohibitively expensive. We look forward to seeing SITELLE in action at CFHT, sometime during the end of 2013.

IMAKA Development Program

The IMAKA team conducted a pair of observing runs on the UH 2.2 m and later over a 7 night stretch at the CFHT Prime Focus. These tests were designed to characterize in great detail the line-of-sight optical turbulence above the upper ridge on Mauna Kea including contributions from the telescope enclosures.

Core members of the mWFS (multi-wavefront sensor) team included Mark Chun (UH), Doug Toomey (MKIR), Tim Butterley (Durham), and Olivier Lai (CFHT). The test equipment consisted of 5 high order Shack-Hartmann wavefront sensors that are precisely mounted to point at bright stars in pre-selected star clusters while co-aligning their pupil images on the telescope entrance aperture. Meeting all of these boundary conditions was non-trivial from an opto-mechanical standpoint and the team found that very little adjustment was needed when the system was trained on the sky. Observations generated terabytes of synchronous wavefront telemetry from the sensors, sampling a variety of atmospheric conditions at hundreds of frames per second. CFHT programmed MKAM (the facility seeing monitor on Mauna Kea) to observe the same fields in the sky using MKAM's DIMM and MASS instruments, thereby yielding measurements that did not include dome seeing.

The basic questions the experiment will answer are (1) where and how strong is the optical turbulence within the ground layer and dome, (2) what is the correlation of the atmospheric wavefront phase over degree sized fields of view and (3) what is the efficacy of GLAO correction over these fields of view? During the four nights at the UH 2.2 m telescope the optical turbulence near the ground was confined to within the first few tens of meters. The GLAO correction, estimated from these data, delivers an image quality approaching the free-atmosphere seeing (as measured by the MKAM MASS) at the time.
The ~ 9 TBytes of CFHT data are now being analyzed by Chun (using a Zernike fitting technique), Butterley (using a SLODAR method), and Lai (using a complex wavefront covariance scheme). We expect an initial report on Phase A of IMAKA during the spring 2013 SAC meeting, with a final report to be completed by mid-2013. The product of these analyses can be fed into GLAO performance models. It should be possible to derive a synthetic PSF from the covariance matrices and choice of reconstructor.

Note that IMAKA is currently only funded through this phase A – a development step deemed necessary under any circumstances to validate assumptions about the Mauna Kea ground layer. Given the unique nature of these measurements we are confident that the IMAKA data will be of broad interest to AO groups worldwide. For 2013 Chun is pursuing NSF/ATI funding for related AO systems at the UH 2.2 m and a decision to further develop IMAKA at CFHT depends upon many factors, including the outcome of these measurements (which critically inform determinations of the technical feasibility of IMAKA), the availability of funding from CFHT, and the possible injection of resources from other groups interested in partnering on IMAKA.

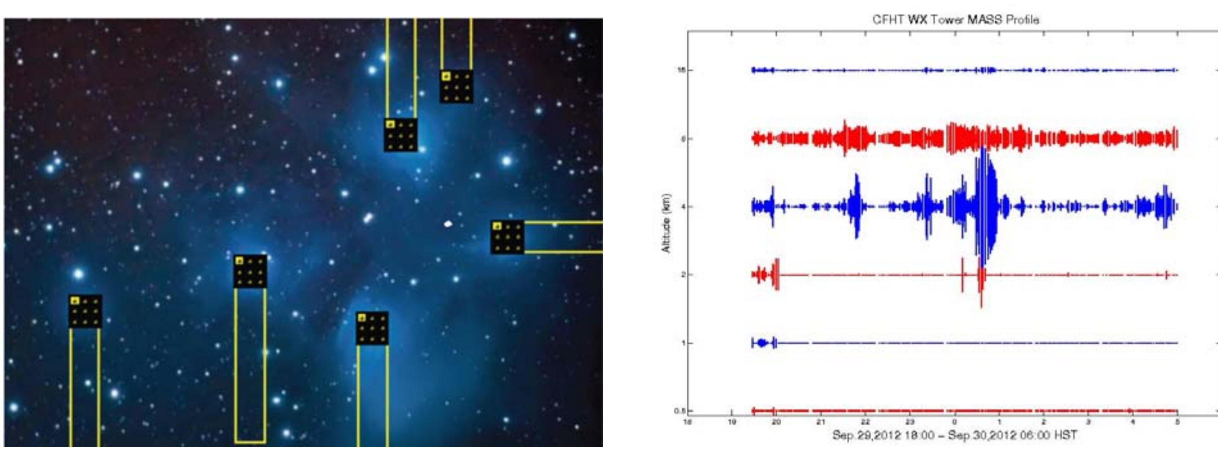


Figure 16 - On the left, the CFHT configuration of the mWFS system, showing schematically the locations of the wavefront sensors pointed at the brightest stars in the Pleiades. On the right is the MKAM MASS data during one of the nights the mWFS system was used on the UH 2.2 m. Note the weak ground layer and fairly strong turbulence at mid-levels in the atmosphere.

GRACES – Phase 1

Graces is a joint CFHT/Gemini -North experiment funded by Gemini to assess the feasibility of feeding the ESPaDOnS spectrograph at CFHT from Gemini-North using an optical fiber. This is a unique attempt to share instrumentation across the Mauna Kea observatories, taking advantage of optical fiber technologies and a pre-existing conduit between Gemini-North and CFHT to route the fiber between these two neighboring facilities. Some of the primary goals of Phase 1 include verifying that the total system throughput renders a scientifically compelling capability, target acquisition in the GMOS fiber cartridge is robust, data and control systems work properly across both observatories, and various opto-mechanical interface issues are resolved adequately. Phase 2 is envisioned to be a full facility-class version of this system, featuring more extensive control software that will make it possible to operate the instrument in the Gemini queue (as opposed to an engineering environment) and perhaps some modest upgrades deemed useful during the Phase 1 tests. In any case, a decision to further develop GRACES from its Phase 1 experimental stage to a new facility available to the Gemini community depends critically on the performance of the system during the culmination of the Phase 1 tests.

Figure 17 – The mWFS assembly in the lab at MKIR in Hilo is shown. The assembly consists of 5 high order/speed wavefront sensors and a commercial camera for acquisition purposes.

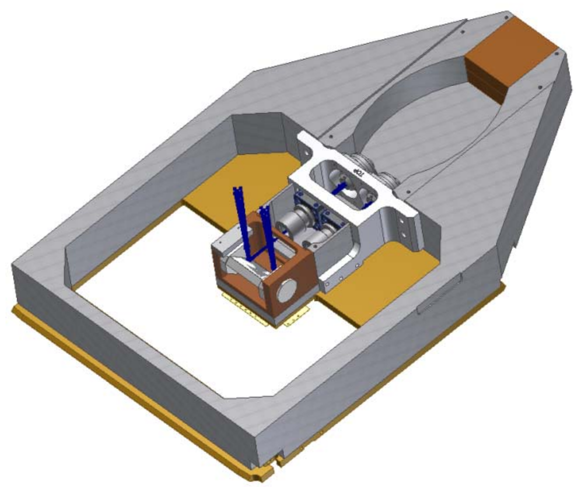


Figure 18 – A CAD rendering of the GRACES fiber front-end feed in GMOS-N is shown.

Most of the necessary hardware – fibers, image slices, fiber feeds, etc. – are being developed at NRC Herzberg, Canada. We expect spectral resolution of 50,000 to 55,000 in star-only mode and between 30,000 and 34,000 in star-plus-sky mode. GRACES's performance should compare favorably with other spectrographs at red wavelengths. An optical feed mechanism has been developed by NRC Herzberg that allows insertion of the light from the GRACES fiber into the spectrograph without disturbing the optics for the ESPaDOnS fiber feed. This feed is mounted in a frame that straddles the ESPaDOnS beam and contains a separate set of insertion optics. The fiber will enter the spectrograph from above and the beam will be redirected into the spectrograph optical path using a movable fold mirror. On the other end, a cartridge assembly, compatible with the space envelope of GMOS IFU cartridges, will be deployed remotely in GMOS-N when this mode is used. Fields will be imaged first in GMOS and then pointing offsets calculated to position the science target at the fiber entrance pupil. The image slicers, fibers and injection modules are expected to be delivered to Hawaii in time for an early summer, 2013 first light observing run.

Administration Report

Summary of 2012 Finances

Contributions from the three Member Agencies supporting CFHT's base annual budget in 2012 are shown in Table 1. These contributions reflect a 4.5% increase in 2012 over the prior year. Under collaborative agreements with CFHT, the Academia Sinica Institute of Astronomy and Astrophysics of Taiwan, the Brazilian Ministry of Science, Technology and Innovation, the National Astronomical Observatory of China, and the Korean Astronomy and Space Science Institute collectively remitted $1,402,583 for costs associated with their use of the Corporation's facilities. Other sources of funds included $18,753 from mid-level facility use credits, $33,304 from distribution of educational materials, $9,971 in staffing cost reimbursements related to work done for other Mauna Kea facilities, and $22,216 in earned interest. From the operating fund, 2012 expenditures were allocated to the areas listed in Table 2. Overall, resources from all CFHT funds were allocated to the categories of expenditures shown in the pie chart in Figure 19.

Agency Contributions (US$)	
NRC	3,112,384
CNRS	3,112,384
UH	721,710
Total	6,946,478

Table 1 – Contributions from each partner in CFHT Corp. are listed.

Operating Fund Expenditures (US$)	
Observatory facilities and operations	752,190
Base facilities and operations	585,270
Instrumentation	49,771
Science	117,514
Outreach	34,459
General administrative expenses	390,565
Staffing	4,850,709
Transfer to Reserve	166,000
Total	6,946,748

Table 2- Operating expenditures are broken down into various cost categories.

Administrative Activities

Among the accomplishments of the administrative group in 2012 was the organization of a staff survey with SHRM Hawaii (Society for Human Resource Management Hawaii Chapter). This survey was part of a broader set of surveys that SHRM Hawaii conducts annually with organizations across the state. It was web based and consisted of ~50 questions for which participants are asked on a sliding scale to "agree" or "disagree" about various aspects of their workplace. All information provided by employees was entirely confidential with SHRM Hawaii only providing to CFHT a statistical analysis of the results, compared to other organizations in Hawaii who have taken the same survey. At our request the survey was customized by adding 6 questions that the staff devised to assess perspectives on issues that are specific to CFHT. The survey participation rate at CFHT was 93%, ensuring that the results captured in the survey reflect staff-wide sentiments. Figure 20 shows an extract from the report which lists results for each question posed, breaking out the largest (i.e., statistically significant) groups in the process, and comparing all results to the state-wide results. Finally, the end of the survey included two questions –

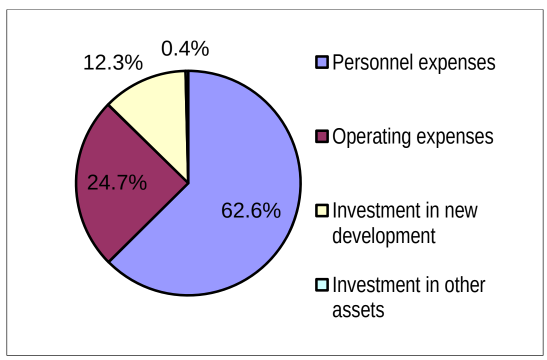


Figure 19 – The high-level distribution of expenditures across the entire observatory is plotted.

"Please share any comments you have about the most positive aspect(s) of working here for you personally"

"Please share one or two changes you think would make us more effective or competitive."

Question	Group	N Size	Percentage of People Responding: Favorable	Neutral	Unfavorable	Percentage: SA 5	A 4	Neu 3	D 2	SD 1	Change: % Fav ⬆⬇
Engagement - E1. Considering everything, how would you rate this organization as a place to work? (Very Poor - Very Good)	CFH Telescope Corp	35	94%			80	14	6	0	0	
	Astronomy	10	90%	10%		70	20	10	0	0	
	Instrument	5	100%			80	20	0	0	0	
	Operations	7	100%			86	14	0	0	0	
	Software	6	84%	17%		67	17	17	0	0	
	Hawaii Average		72%	20%	9%						

Figure 20 – An example of the staff survey results provided by SHRM Hawaii, showing the results for the entire observatory along the top, the 4 groups largest enough to represent statistically in the survey across the middle, and the average for all organizations across Hawaii who participated in the survey along the bottom.

The results of the staff survey were immediately circulated to the staff, in their entirety, once they arrived and were discussed in various group meetings. They were also discussed during the monthly "talk story" staff-wide meetings as well, to explore issues and develop action plans to address any areas that were felt to need improvement. Overall we were pleased with the process, participation level, and product of this survey. The survey shed light on certain aspects of the organization that need improvement, which was why we conducted the survey in the first place.

Another significant contribution and innovation developed by the administrative group in 2012 was the implementation of Concur – a commercial software package for booking travel arrangements. Concur was customized to CFHT's travel policies and was released just in time for Board and SAC members travel in the fall. Concur features end-to-end support of travel, from requesting travel approval to completing travel expense reports in a semi-automatic manner, with direct data feeds from charge cards, automatic distance calculations for computing mileage, etc.

Finally, CFHT was invited to participate in a study conducted by the French Ministry of Higher Education and Research. The main objectives of the study were to –

- "increase the competitiveness of European scientific organizations by extending their use of large research infrastructures"
- "develop self-generated funding"
- "make academic users aware of the costs of … infrastructures"

The findings of the study were that CFHT operates at full capacity and no self-generating funding sources were identified.

Staff Safety

The CFHT safety program continually strives to keep our staff and guests safe in all that they do. This commitment is reflected in the annual Work-Related Injuries and Illnesses Report summarized in Table 3. This record allowed CFHT to be recognized for its excellence in safety by the State of Hawaii in recent years.

All members of the staff regularly participate in safety activities, including group discussions, periodic training and program reviews. In addition, the following efforts were undertaken in 2012:

- Deficiencies identified during the 2011 biennial safety walk through were abated with a few larger projects budgeted for 2013.
- A specialized training program was developed for astronomy staff members that conduct dome assessments with a remote observer during inclement weather. The program includes training in dome operations, lockout/tagout procedures, and man-lift operations.

- A process was developed to evaluate potential hazards that students and visiting astronomers will be exposed to and appropriate safety training is now provided upon their arrival.

	2012	2011	2010	2009	2008	2007	2006	2005
Injuries	0	1	0	0	0	1	0	0
Illnesses	0	0	0	0	0	0	0	0
Lost work days	0	1	0	0	0	1	0	0

Table 3 – Nearly a decade of top-level statistics pertaining to safety are listed above.

Building Improvements

We recently began to give the CFHT headquarters an updated look by removing the orange-metal drop ceilings from our hallways. To keep the cost to a minimum, the work is being done by our very talented, Roger Wood. In addition to the removal of the drop ceilings, Roger will be giving the hallways a new paint job, finishing the windows with custom framing, and installing new lighting. We also expect to see an updated collection of CFHT art on the walls.

Other major projects planned for the coming year include the replacement of the flooring in the electronics lab, repainting of the roof and the installation of two photo-voltaic systems on our main and shop buildings.

Our front lobby was also given a “face lift”. New staff photos were taken, organized, and printed by Jean-Charles Cuillandre, while Kanoa Withington mounted the montage for display in the front lobby area, while each staff member provided a happy smile!

Figure 21 – The interior of the Waimea office is getting a facelift by removing all of the original orange metal ceiling material (left), letting in much more natural lighting and taking advantage of the high ceilings originally designed into the building (right).

Figure 22 – A new staff photo gallery was placed in the front lobby of the Waimea office. Special thanks to Jean-Charles Cuillandre and Kanoa Withington for their efforts to make this possible!

The Personal Touch

In 2012, we had no departures and welcomed four new staff members.

Greg Green

Greg Green arrived at CFHT in June 2012 to join our Operations group as a machinist/instrument designer, bringing a broad range of experience. Prior to joining CFHT, Greg was a CNC machinist at Accutech CNC creating prototype parts primarily for the automotive and office furniture industries as well as military contracts, highly sensitive medical prototypes and nuclear projects. As a hobby, Greg builds custom motorcycles and hot rods and has had success at the highest international level of custom motorcycle competition. Both Greg and his wife Jennifer look forward to starting a new life in Hawaii and with the CFHT family.

Tien Nguyen

Tien Nguyen joined the Corporation in July 2012 as a Systems Administrator. His main duties are maintaining and enhancing the computer systems and applications used by CFHT's staff and scientists on a daily basis. Before coming to CFHT, Tien was doing systems administration at the Neurological Institute of Montreal, in a group conducting brain imaging research within the CANARIE sponsored project Canadian Brain Research Network (CBrain). In his spare time, he enjoys exploring the unique beauty of the Big Island.

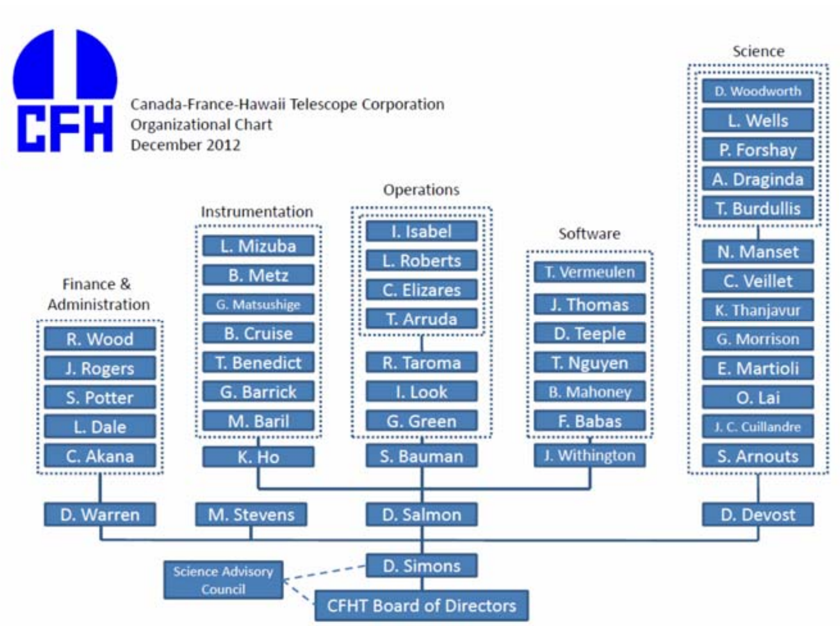
Brandon Metz

Brandon Metz joined CFHT's instrumentation group in the third quarter of 2012. With a strong background in robotics, Brandon's first project is the Telescope Control System (TCS) upgrade as well as dome shutter investigations. Brandon started his career working at a laser welding systems company that built many automated machines for the medical, automotive, and military industries. Later he went on to join the Jet Propulsion Laboratory (JPL) to work further in the field of robotics and vision systems. While at JPL he worked for 5 years on the Mars Curiosity Rover working intimately with its mechanisms and the motor control assembly. The Curiosity rover successfully touched down on Mars in early August of 2012 and after working 25 sols (Mars days) he left to start his new career at CFHT. Brandon has hobbies in software defined radio, motor controllers, amateur astrophotography, machining, and surfing.

Doug Simons

Doug Simons (re)joined CFHT on 1 May 2012. Doug graduated from Caltech with his B.Sc. in astronomy from Caltech in 1985, then received his PhD in astronomy from the University of Hawaii in 1990 before joining CFHT as the UH sponsored resident astronomer. While there he led the development of CFHT's first facility infrared array cameras. In 1994 he joined the Gemini 8 m Telescopes Project in Tucson as Systems Scientist, where he stayed for 18 years, the last 5 of which as Gemini Director. He now joins CFHT as Executive Director. Doug enjoys woodworking, fishing, and upland game bird hunting and together with his wife Judy has raised 3 kids, Kirstie, Chris, and Jacob.

Organization Chart and Staff List



Name	Position	Name	Position
Akana, Maoni	Administrative Specialist	**Manset, Nadine**	Resident Astronomer
Arnouts, Stéphane	Resident Astronomer	**Martioli, Eder**	Resident Astronomer
Arruda, Tyson	Mechanical Technician	**Matsushige, Grant**	Sr. Instrument Specialist
Babas, Ferdinand	System Administrator	**Metz, Brandon**	Instrument Engineer
Baril, Marc	Instrument Engineer	**Mizuba, Les**	Instrument Specialist
Barrick, Gregory	Optical Engineer	**Morrison, Glenn**	Resident Astronomer
Bauman, Steven	Operations Mgr/Mechanical Eng	**Nguyen, Tien**	System Administrator
Benedict, Tom	Instrument Specialist	**Roberts, Larry**	Electrician
Burdullis, Todd	QSO Operations Specialist	**Rodgers, Jane**	Finance Manager
Cruise, Bill	Telescope Control Sys Engineer	**Salmon, Derrick**	Director of Engineering
Cuillandre, Jean-Charles	Staff Astronomer	**Simons, Doug**	Executive Director
Dale, Laurie	Administrative Specialist	**Stevens, Mercédes**	Assistant to the Exec Director
Devost, Daniel	Director of Science Operations	**Taroma, Ralph**	Observatory Facility Manager
Draginda, Adam	Remote Observer	**Teeple, Doug**	System Programmer
Elizares, Casey	Mechanical Technician	**Thanjavur, Karun**	Resident Astronomer
Forshay, Peter	Remote Observer	**Thomas, Jim**	Computer Software Engineer
Green, Greg	Mech Designer/Instrument Maker	**Veillet, Christian**	Resident Astronomer
Ho, Kevin	Instrument Manager	**Vermeulen, Tom**	System Programmer
Isabel, Ilima	Custodian	**Warren, DeeDee**	Director of Finance & Administration
Lai, Olivier	Resident Astronomer	**Wells, Lisa**	Remote Observer
Look, Ivan	Mechanical Design Engineer	**Withington, Kanoa**	Software Manager
Mahoney, Billy	Database Specialist	**Wood, Roger**	Automotive Mechanic
		Woodworth, David	Remote Observer

Outreach Report

CFHT remained active on various outreach fronts during 2012 and a montage of photos appears here which captures many of these events. These included participation in the first ever Akamai Career Exploration Course, the OMKM organized removal of invasive species around the Mauna Kea mid-level facilities, the 2012 International Observe the Moon Night, the “Adopt a Highway” program with Keck, and the Solar System Walk, also a collaboration with Keck. The latter features stations scattered between the Keck and CFHT offices, each housing an activity based upon one of the planets (as well as the main asteroid and Kuiper belts). As kids walk through the “solar system” they are treated to a variety of activities about the solar system before arriving on the CFHT lawn for a BBQ lunch. The main public outreach project during the final quarter of 2012 was the annual December star party on the front lawn of CFHT’s office, which is always popular if not a bit chilly.

By far the largest outreach event in 2012 was the Venus transit, in which CFHT and Keck opened their doors in Waimea for public viewing using a variety of telescopes. An estimated ~500 people came through the CFHT front doors to peer at this rare event, making it one of the largest outreach events in CFHT history. Luckily the CFHT staff is replete with talented engineers and scientists who could outfit a range of small telescopes for safe solar viewing. Thanks to the weather conditions, only the Waimea based observatory offices were able to treat the public to views of the transit. The fact that so many people came to witness this event, in a town the size of Waimea, demonstrates the keen interest the local community has in astronomy in general and the Mauna Kea Observatories in particular.

Figure 23 – On September 29 CFHT and Keck held the annual solar system walk across Waimea, which starts at Keck (the Sun) and ends at CFHT (KBO’s). Kids are greeted at each station with an activity and fill out their “passports” on the way to CFHT, where they were greeted with a lunch.

Figure 24 – In August and September a team of volunteers, including several from CFHT, participated in a project organized by OMKM to remove invasive plant species from the vicinity of HP and the VIS. Thirty large bags of weeds were removed, helping make room for a future planting of native Hawaiian flora in the area.

Figure 25 – CFHT helped host the first-ever Akamai Career Exploration Course. From Lisa Hunter, the program organizer, "The students learned a great deal about who works at observatories, and how they got there through the interviews they did with you."

Figure 26 – Left: CFHT opened its doors to the community and thanks to clear skies was (along with Keck) the only astronomy office able to show the public the transit of Venus in June. This outreach event was a spectacular success, with ~500 people, including many keiki, flooding into the CFHT/HQ courtyard to view the event through telescopes set up by the CFHT staff. Right: Another example of Keck/CFHT community involvement is the "Adopt a Highway" program which keeps a ~1 mile stretch of the road outside Waimea clean.

2012 Publications

Kuzio de Naray, R., et al., Searching for non-axisymmetries in NGC 6503: a weak end-on bar, 12/2012, MNRAS, 427, 2523

Hoekstra, H., et al., The Canadian Cluster Comparison Project: weak lensing masses and SZ scaling relations, 12/2012, MNRAS, 427, 1298

Hsieh, B.-C., et al., The Taiwan ECDFS Near-Infrared Survey: Ultra-deep J and K_S Imaging in the Extended Chandra Deep Field-South, 12/2012, ApJS, 203, 23

Davidge, T. J., The Young Open Clusters King 12, NGC 7788, and NGC 7790: Pre-main-sequence Stars and Extended Stellar Halos, 12/2012, ApJ, 761, 155

Kong, A. K. H., Optical Emission of the Black Hole X-Ray Transient MAXI J1659-152 during Quiescence, 12/2012, ApJ, 760, L27

Carroll, T. A., et al., The magnetic field topology of the weak-lined T Tauri star V410 Tauri. New strategies for Zeeman-Doppler imaging, 12/2012, A&A, 548, A95

Siqueira Mello, C., et al., Origin of the heavy elements in HD 140283. Measurement of europium abundance, 12/2012, A&A, 548, A42

Kim, S. J., et al., The North Ecliptic Pole Wide survey of AKARI: a near-and mid-infrared source catalog, 12/2012, A&A, 548, A29

Delorme, P., et al., CFBDSIR2149-0403: a 4-7 Jupiter-mass free-floating planet in the young moving group AB Doradus?, 12/2012, A&A, 548, A26

Castagné;, D., et al., Deep optical observations of the massive galaxy cluster Abell 1413, 12/2012, A&A, 548, A18

Cooke, J., et al., Superluminous supernovae at redshifts of 2.05 and 3.90, 11/2012, Natur, 491, 228

Ceus, D., et al., Application of frequency conversion of starlight to high-resolution imaging interferometry. On-sky sensitivity test of a single arm of the interferometer, 11/2012, MNRAS, 427, L95

Khalack, V., Landstreet, J. D., Partial Paschen-Back splitting of Si II and Si III lines in magnetic chemically peculiar stars, 11/2012, MNRAS, 427, 569

Lidman, C., et al., Evidence for significant growth in the stellar mass of brightest cluster galaxies over the past 10 billion years, 11/2012, MNRAS, 427, 550

Jauzac, M., et al., A weak lensing mass reconstruction of the large-scale filament feeding the massive galaxy cluster MACS J0717.5+3745, 11/2012, MNRAS, 426, 3369

Neiner, C., et al., An investigation of the magnetic properties of the classical Be star Ω ; Ori by the MiMeS Collaboration, 11/2012, MNRAS, 426, 2738

Grunhut, J. H., et al., Investigating the spectroscopic, magnetic and circumstellar variability of the O9 subgiant star HD 57682, 11/2012, MNRAS, 426, 2208

Geise, K., et al., Eclipse Spectropolarimetry of the Îµ Aurigae System, 11/2012, JAVSO, 40, 767

Shinn, J.-H., Lee, H.-G., Moon, D.-S., Ortho-to-para Ratio Studies of Shocked H_2 Gas in the Two Supernova Remnants IC 443 and HB 21, 11/2012, ApJ, 759, 34

Stevenson, R., Jewitt, D., Near-nucleus Photometry of Outbursting Comet 17P/Holmes, 11/2012, AJ, 144, 138

Jacobson, R., et al., Irregular Satellites of the Outer Planets: Orbital Uncertainties and Astrometric Recoveries in 2009-2011, 11/2012, AJ, 144, 132

Adams, S. M., et al., The Environmental Dependence of the Incidence of Galactic Tidal Features, 11/2012, AJ, 144, 128

Alves, J., Bouy, H., Orion revisited. I. The massive cluster in front of the Orion nebula cluster, 11/2012, A&A, 547, A97

Silvester, J., et al., Stokes IQUV magnetic Doppler imaging of Ap stars - I. ESPaDOnS and NARVAL observations, 10/2012, MNRAS, 426, 1003

Donati, J.-F., et al., Magnetometry of the classical T Tauri star GQ Lup: non-stationary dynamos and spin evolution of young Suns, 10/2012, MNRAS, 425, 2948

Shkolnik, E. L., et al., Identifying the Young Low-mass Stars within 25 pc. II. Distances, Kinematics, and Group Membership, 10/2012, ApJ, 758, 56

Foëx, G., et al., The dark matter distribution in z ~ 0.5 clusters of galaxies. I. Determining scaling relations with weak lensing masses, 10/2012, A&A, 546, A106

Lee, S. H., Kang, Y.-W., Ann, H. B., Deep and wide photometry of the two open clusters NGC 1245 and NGC 2506: CCD observation and physical properties, 9/2012, MNRAS, 425, 1567

Wade, G. A., et al., NGC 1624-2: a slowly rotating, X-ray luminous Of?cp star with an extraordinarily strong magnetic field, 9/2012, MNRAS, 425, 1278

Lusso, E., et al., Bolometric luminosities and Eddington ratios of X-ray selected active galactic nuclei in the XMM-COSMOS survey, 9/2012, MNRAS, 425, 623

Bildfell, C., et al., Evolution of the red sequence giant to dwarf ratio in galaxy clusters out to z 0.5, 9/2012, MNRAS, 425, 204

Harris, A. W., Pravec, P., Warner, B. D., Looking a gift horse in the mouth: Evaluation of wide-field asteroid photometric surveys, 9/2012, Icar, 221, 226

Barnes, K. L., et al., Star Formation in the Outer Disk of Spiral Galaxies, 9/2012, ApJ, 757, 64

Connelly, J. L., et al., Exploring the Diversity of Groups at 0.1 < z < 0.8 with X-Ray and Optically Selected Samples, 9/2012, ApJ, 756, 139

Van Dyk, S. D., et al., The Red Supergiant Progenitor of Supernova 2012aw (PTF12bvh) in Messier 95, 9/2012, ApJ, 756, 131

Lin, L., et al., Clustering Properties of BzK-selected Galaxies in GOODS-N: Environmental Quenching and Triggering of Star Formation at z ~ 2, 9/2012, ApJ, 756, 71

Fliri, J., Valls-Gabaud, D., First results from the POMME survey of M31, 9/2012, Ap&SS, 341, 57

Henrichs, H. F., et al., Discovery of a magnetic field in the early B-type star σ Lupi, 9/2012, A&A, 545, A119

Spezzi, L., et al., Searching for planetary-mass T-dwarfs in the core of Serpens, 9/2012, A&A, 545, A105

Bielby, R., et al., The WIRCam Deep Survey. I. Counts, colours, and mass-functions derived from near-infrared imaging in the CFHTLS deep fields, 9/2012, A&A, 545, A23

Dupuy, T. J., Liu, M. C., The Hawaii Infrared Parallax Program. I. Ultracool Binaries and the L/T Transition, 8/2012, ApJS, 201, 19

Ford, J., et al., Magnification by Galaxy Group Dark Matter Halos, 8/2012, ApJ, 754, 143

Keenan, R. C., et al., Testing for a Large Local Void by Investigating the Near-infrared Galaxy Luminosity Function, 8/2012, ApJ, 754, 131

Beccari, G., et al., The Central Blue Straggler Population in Four Outer-halo Globular Clusters, 8/2012, ApJ, 754, 108

Perrett, K., et al., Evolution in the Volumetric Type Ia Supernova Rate from the Supernova Legacy Survey, 8/2012, AJ, 144, 59

Rodríguez-Ledesma, M. V., et al., An unusual very low-mass high-amplitude pre-main sequence periodic variable, 8/2012, A&A, 544, A112

Muñoz, R. R., et al., The Discovery of an Ultra-faint Star Cluster in the Constellation of Ursa Minor, 7/2012, ApJ, 753, L15

Walsh, J. L., et al., A Stellar Dynamical Mass Measurement of the Black Hole in NGC 3998 from Keck Adaptive Optics Observations, 7/2012, ApJ, 753, 79

Graham, M. L., et al., The Type II Supernova Rate in z ~ 0.1 Galaxy Clusters from the Multi-Epoch Nearby Cluster Survey, 7/2012, ApJ, 753, 68

Chun, S.-H., et al., A Feature of Stellar Density Distribution within the Tidal Radius of Globular Cluster NGC 6626 (M28) in the Galactic Bulge, 7/2012, AJ, 144, 26

Gladman, B., et al., The Resonant Trans-Neptunian Populations, 7/2012, AJ, 144, 23

Alexandersen, M., et al., Discovery of Two Additional Jovian Irregulars, 7/2012, AJ, 144, 21

Thygesen, A. O., et al., Atmospheric parameters of 82 red giants in the Kepler field, 7/2012, A&A, 543, A160

Jung, M. Y., et al., Near-infrared properties of asymptotic giant branch stars in nearby dwarf elliptical galaxy NGC 205, 7/2012, A&A, 543, A35

Fares, R., et al., Magnetic field, differential rotation and activity of the hot-Jupiter-hosting star HD 179949, 6/2012, MNRAS, 423, 1006

Bailey, J. D., et al., An analysis of the rapidly rotating Bp star HD 133880, 6/2012, MNRAS, 423, 328

McAlpine, K., et al., The likelihood ratio as a tool for radio continuum surveys with Square Kilometre Array precursor telescopes, 6/2012, MNRAS, 423, 132

Bruntt, H., et al., Accurate fundamental parameters and detailed abundance patterns from spectroscopy of 93 solar-type Kepler targets, 6/2012, MNRAS, 423, 122

De Rosa, R. J., et al., The Volume-limited A-Star (VAST) survey - II. Orbital motion monitoring of A-type star multiples, 6/2012, MNRAS, 422, 2765

Dalcanton, J. J., et al., The Panchromatic Hubble Andromeda Treasury, 6/2012, ApJS, 200, 18

Fang, G., et al., Passive and Star-forming Galaxies at 1.4 <= z <= 2.5 in the AEGIS Field, 6/2012, ApJ, 751, 109

Britavskiy, N. E., et al., Chemical composition of semi-regular variable giants. III., 6/2012, A&A, 542, A104

Zajczyk, A., et al., Infrared imaging and polarimetric observations of the pulsar wind nebula in SNR G21.5-0.9, 6/2012, A&A, 542, A12

Coupon, J., et al., Galaxy clustering in the CFHTLS-Wide: the changing relationship between galaxies and haloes since z ~ 1.2*, 6/2012, A&A, 542, A5

Folsom, C. P., et al., Chemical abundances of magnetic and non-magnetic Herbig Ae/Be stars, 5/2012, MNRAS, 422, 2072

Sanna, N., et al., The blue straggler star population in NGC 6229, 5/2012, MNRAS, 422, 1171

Griffith, R. L., et al., The Advanced Camera for Surveys General Catalog: Structural Parameters for Approximately Half a Million Galaxies, 5/2012, ApJS, 200, 9

Ferrarese, L., et al., The Next Generation Virgo Cluster Survey (NGVS). I. Introduction to the Survey, 5/2012, ApJS, 200, 4

Davidge, T. J., et al., The Recent Stellar Archeology of M31 -- The Nearest Red Disk Galaxy, 5/2012, ApJ, 751, 74

Cieza, L. A., et al., The Nature of Transition Circumstellar Disks. III. Perseus, Taurus, and Auriga, 5/2012, ApJ, 750, 157

Shultz, M., et al., Critical Evaluation of Magnetic Field Detections Reported for Pulsating B-type Stars in Light of ESPaDOnS, Narval, and Reanalyzed FORS1/2 Observations, 5/2012, ApJ, 750, 2

Alencar, S. H. P., et al., Accretion dynamics in the classical T Tauri star V2129 Ophiuchi, 5/2012, A&A, 541, A116

Kervella, P., et al., The long-period Galactic Cepheid RS Puppis. II. 3D structure and mass of the nebula from VLT/FORS polarimetry, 5/2012, A&A, 541, A18

Smith, R. J., Lucey, J. R., Carter, D., What drives the ultraviolet colours of passive galaxies?, 4/2012, MNRAS, 421, 2982

Verdugo, M., et al., The Cosmic Web and galaxy evolution around the most luminous X-ray cluster: RX J1347.5-1145, 4/2012, MNRAS, 421, 1949

Davidge, T. J., A Large Group of Asymptotic Giant Branch Stars in the Disk of M31: A Missing Piece of the Puzzle?, 4/2012, ApJ, 749, L7

Li, I. H., et al., Evolution of Group Galaxies from the First Red-Sequence Cluster Survey, 4/2012, ApJ, 749, 150

Guo, Y., et al., Rest-frame UV-Optically Selected Galaxies at 2.3 <~ z <~ 3.5: Searching for Dusty Star-forming and Passively Evolving Galaxies, 4/2012, ApJ, 749, 149

Hsieh, B.-C., et al., The Taiwan ECDFS Near-Infrared Survey: Very Bright End of the Luminosity Function at z > 7, 4/2012, ApJ, 749, 88

More, A., et al., The CFHTLS-Strong Lensing Legacy Survey (SL2S): Investigating the Group-scale Lenses with the SARCS Sample, 4/2012, ApJ, 749, 38

Anguita, T., et al., Galaxy Scale Lenses in the RCS2. I. First Catalog of Candidate Strong Lenses, 4/2012, ApJ, 748, 129

Nissen, H. D., et al., A 3D view of the outflow in the Orion Molecular Cloud 1 (OMC-1), 4/2012, A&A, 540, A119

Soucail, G., Dark matter distribution in the merging cluster Abell 2163, 4/2012, A&A, 540, A61

McCall, M. L., et al., Fundamentals of the dwarf fundamental plane, 4/2012, A&A, 540, A49

Boschin, W., et al., Abell 1758N from an optical point of view: new insights on a merging cluster with diffuse radio emission, 4/2012, A&A, 540, A43

Urata, Y., et al., Energetic Fermi/LAT GRB 100414A: Energetic and Correlations, 3/2012, ApJ, 748, L4

Shan, H., et al., Weak Lensing Measurement of Galaxy Clusters in the CFHTLS-Wide Survey, 3/2012, ApJ, 748, 56

Huang, K. Y., et al., GRB 071112C: A Case Study of Different Mechanisms in X-Ray and Optical Temporal Evolution, 3/2012, ApJ, 748, 44

Li, I. H., et al., The WiggleZ Dark Energy Survey: Galaxy Evolution at 0.25 <= z <= 0.75 Using the Second Red-Sequence Cluster Survey, 3/2012, ApJ, 747, 91

Xu, C. K., et al., Major-merger Galaxy Pairs in the COSMOS Field -- Mass-dependent Merger Rate Evolution since z = 1, 3/2012, ApJ, 747, 85

Ideue, Y., et al., The Role of Galaxy Interaction in Environmental Dependence of the Star Formation Activity at z ~= 1.2, 3/2012, ApJ, 747, 42

Alves de Oliveira, C., et al., Spectroscopy of new brown dwarf members of ρ Ophiuchi and an updated initial mass function, 3/2012, A&A, 539, A151

Epinat, B., et al., MASSIV: Mass Assembly Survey with SINFONI in VVDS. II. Kinematics and close environment classification, 3/2012, A&A, 539, A92

Cucciati, O., et al., The star formation rate density and dust attenuation evolution over 12 Gyr with the VVDS surveys, 3/2012, A&A, 539, A31

Spinelli, P. F., et al., Weak-lensing mass estimates of galaxy groups and the line-of-sight contamination, 2/2012, MNRAS, 420, 1384

Petit, V., Wade, G. A., Stellar magnetic field parameters from a Bayesian analysis of high-resolution spectropolarimetric observations, 2/2012, MNRAS, 420, 773

Findlay, J. R., et al., Selection constraints on high-redshift quasar searches in the VISTA Kilo-degree Infrared Galaxy survey, 2/2012, MNRAS, 419, 3354

Sand, D. J., et al., The Multi-Epoch nearby Cluster Survey: Type Ia Supernova Rate Measurement in z ~ 0.1 Clusters and the Late-time Delay Time Distribution, 2/2012, ApJ, 746, 163

Aird, J., et al., PRIMUS: The Dependence of AGN Accretion on Host Stellar Mass and Color, 2/2012, ApJ, 746, 90

Carone, L., et al., Planetary transit candidates in the CoRoT LRa01 field, 2/2012, A&A, 538, A112

Lieder, S., et al., A deep view on the Virgo cluster core, 2/2012, A&A, 538, A69

Clément, B., et al., Evolution of the observed Lyα luminosity function from z = 6.5 to z = 7.7: evidence for the epoch of reionization?, 2/2012, A&A, 538, A66

Martins, F., et al., Observational effects of magnetism in O stars: surface nitrogen abundances, 2/2012, A&A, 538, A29

Wade, G. A., et al., The spectral variability and magnetic field characteristics of the Of?p star HD 148937, 1/2012, MNRAS, 419, 2459

Grunhut, J. H., et al., HR 5907: Discovery of the most rapidly rotating magnetic early B-type star by the MiMeS Collaboration, 1/2012, MNRAS, 419, 1610

Oksala, M. E., et al., Revisiting the Rigidly Rotating Magnetosphere model for σ Ori E - I. Observations and data analysis, 1/2012, MNRAS, 419, 959

Gosnell, N. M., et al., An Unexpected Discovery in the Rich Open Cluster NGC 6819 Using XMM-Newton, 1/2012, ApJ, 745, 57

González-Gaitán, S., et al., The Rise Time of Normal and Subluminous Type Ia Supernovae, 1/2012, ApJ, 745, 44

Nakajima, K., et al., Average Metallicity and Star Formation Rate of Lyα Emitters Probed by a Triple Narrowband Survey, 1/2012, ApJ, 745, 12

Leauthaud, A., et al., 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, 1/2012, ApJ, 744, 159

Bayliss, M. B., Broadband Photometry of 105 Giant Arcs: Redshift Constraints and Implications for Giant Arc Statistics, 1/2012, ApJ, 744, 156

Wang, W.-H., Barger, A. J., Cowie, L. L., A K_S and IRAC Selection of High-redshift Extremely Red Objects, 1/2012, ApJ, 744, 155

Lim, J., et al., A Molecular Hydrogen Nebula in the Central cD Galaxy of the Perseus Cluster, 1/2012, ApJ, 744, 112

Hodapp, K. W., et al., Eruptive Variable Stars and Outflows in Serpens NW, 1/2012, ApJ, 744, 56

Böhm, T., et al., First evidence of pulsations in Vega?. Results of today's most extensive spectroscopic search, 1/2012, A&A, 537, A90

Raichoor, A., Andreon, S., Star formation and environment in clusters up to z ~ 2.2, 1/2012, A&A, 537, A88

Rouan, D., et al., Transiting exoplanets from the CoRoT space mission . XIX. CoRoT-23b: a dense hot Jupiter on an eccentric orbit, 1/2012, A&A, 537, A54

Takagi, T., et al., The AKARI NEP-Deep survey: a mid-infrared source catalogue, 1/2012, A&A, 537, A24

Tsvetkova, S., et al., Magnetic field and activity of the single late-type giant β Ceti, 0/2012, BlgAJ, 18, 010000