SMALL CANADIAN GROUND-BASED OPTICAL AND INFRARED TELESCOPES: A WHITE PAPER FOR THE 2010 LONG RANGE PLAN

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ABSTRACT

In this paper we summarize the current state of small telescope facilities in Canada, discuss the role such facilities play now and will play in the LRP2010 era, and outline the challenges faced by such telescopes that need to be met in order to enable these goals to be achieved. Both the DAO and OMM telescopes show an increase in productivity when they receive adequate operational and development resources. We therefore recommend that a mechanism be found to allow university facilities such as OMM and RAO to receive funding for their operation and development. We also recommend continued enhanced support for the DAO telescopes at a level of \$100K/year and encourage support for the development of small, modern telescope initiatives at superb sites within Canada.

1. INTRODUCTION

In this era of 8 m and, soon, 30 m telescopes, small ($\leq$ 3.5 m) ground-based optical and infrared telescopes (hereafter simply "small telescopes") continue to serve an important role in Canadian astronomy. They provide opportunities to obtain large blocks of uninterrupted observing time for major surveys or intensive monitoring of individual targets, enable the execution of very long-term monitoring programs and innovative thesis projects, serve as test beds for novel instrument and technology development by students and professional staff, help train HQP and are prominent centerpieces for public outreach activities. However, the recent demise of DDO and UWO facilities demonstrate the challenges faced to maintain these scientifically productive roles.

2. CANADIAN SMALL OPTICAL AND INFRARED TELESCOPES

A summary of currently active small Canadian telescopes is given below. Research facilities 1.2 m and larger are described in some detail while a brief summary is provided for smaller telescopes used primarily for EPO activities. A list of acronyms is given in Table 1.

2.1. *The DAO 1.2 m and 1.8 m Telescopes*

The DAO telescopes are currently the only NRC-supported facilities among the small telescopes. The 1.2 m telescope is used exclusively with the McKellar coudé spectrograph and provides a variety of spectral resolutions up to $R = 40000$. Approximately 30% of the scheduled nights are executed robotically with no interaction from the astronomer. The 1.8 m Plaskett telescope provides imaging at a modified Newtonian focus, long-slit spectroscopy with R between 1000 and 15000 and, most recently, spectropolarimetric capability with $R = 15000$.

While observers on both DAO telescopes continue to carry out the 90+ year tradition of RV and ISM studies at the DAO, recent programs include research by many HIA and visiting astronomers in such diverse areas as comets and asteroids, variable stars, spectroscopy and polarimetry of Ap and Bp stars, SNe, PAGB stars, GC and AGN. Several large programs have been carried out in direct support of CFHT, Gemini, MOST and large international observing programs.

Demand for time on the DAO telescopes continues to exceed the number of nights available and is increasing. Scientific output shown by the number of publications based at least in part on data acquired with the DAO telescopes shows a similar trend (Fig. 1). It is interesting to note that both positive trends began shortly after the injection of modest LRP2000 funds aimed at enhancing the operation of both telescopes.

2.2. *OMM*

OMM with its 1.6 m telescope and instrument facility (LAE, see 3.2.2) is an essential component of the CRAQ. OMM is managed by UdeM (2/3) and ULaval (1/3) and is well equipped with eight state-of-the-art optical and IR instruments due, in a large part, to a major (\$4.7M) upgrade from 1999-2003. Probably no other 1 - 2 m class telescope in the world has such a wide variety of instrumentation. These are excellent tools for providing young astronomers with hands on experience with a modern telescope and optical/IR instrumentation.

OMM provides a unique platform for instrument development and there is particularly good synergy with OMM science and that of 4 - 8 m telescopes. Many of the CRAQ's CFHT and Gemini programs are follow-ups of objects first discovered with the OMM. The telescope subscription rate varies between 1.5 and 2.0 with about 75% of the telescope time awarded to graduate students and the rest to post-docs, faculty and visitors. OMM is also now open to the entire astronomical community and queue-mode observations are supported on a few instruments (IR imager).

The research performed at OMM covers a very broad spectrum from comets, to stars, the ISM and galaxies with data consisting of photometry, spectroscopy and polarimetry in the optical and the NIR. The productivity (Fig. 2) increased after the upgrade, starting in 2003.

2.3. *RAO*

The RAO is an important Canadian observatory with a unique history. It's largest telescope, the 1.8 m ARCT, was designed and built with funds from federal (NSERC), provincial (UofC), and private donor (A.R. Cross) sources. New instrumentation was funded through the Faculty of Science and the research grants of the RAO's co-directors (optical CCD camera, InSb IR photometer). The RAO 0.4 m telescope is equipped with an optical PMT photometer, and a Harvey Richardson optical plate spectrograph. Today the ARCT employs the InSb photometer, an SBIG optical spectrograph, and a focal reducer plus CCD camera.

Between 2000 and 2003 the RAO was upgraded with major provincial infrastructure grants from the Alberta

Science Research Authority. These matching grants enabled the partial automation of the 0.4 m and 1.8 m telescopes and the resurrection of a Baker-Nunn Satellite Tracking Camera (received from the Cold Lake Canadian Forces Base) as the 0.5 m Baker-Nunn Patrol Camera for variable star and asteroid search programs.

Research using the ARCT has historically been in the field of IR passbands. Today the infrared capabilities of the ARCT are used to monitor outbursts of interesting objects (most recently ϵ Aur and WR 140). The Space Science Institute has solicited the help of the RAO's ARCT to assist in the long term IR monitoring of targets including DM Tau, GM Aur, CQ Tau, and HD 31648. However, in recent times only a small amount of research funding from the director emeritus is available to keep the IR observing program alive. The 0.4 m telescope has been used successfully to find asteroids, comets and new variable stars.

The ARCT is used widely for teaching. The opportunity to handle a large telescope and modern instrumentation makes astrophysics come alive for many students. The ability to plan observing sessions, collect and reduce data and then compare one's own observations to theoretical models is a unique and rich educational experience. The top Canadian astronomers of tomorrow will be the product of such opportunities. The Faculty of Science at the UofC provides the funding to keep the ARCT teaching programs alive.

2.4. *Other Facilities*

Table 2 provides a summary of other small Canadian telescopes. While these are often used primarily for EPO, there are a number of research programs carried out on them that are not feasible on larger ground- or space-based facilities. These include, for example, photoelectric photometry of bright stars such as Polaris and time-series photometry providing complete phase coverage of objects with periods of months to years. Photometry of such objects has subsequently been correlated with data from space telescopes such as RXTE, MOST and Spitzer.

There is also clearly community interest in building additional small telescopes at very dark sites within Canada. In one interesting development, the One-Meter Initiative[1] is seeking investors to fund the construction of an innovative, state-of-the-art, wide-field, 1 m imaging telescope that will outperform existing larger instruments (see Roy 2009a,b, for details). This venture is geared as a tourist attraction, but a significant amount of science will also be carried out. Athabasca University is also developing a 0.4 m robotic telescope, AURT. Athabasca's extreme climate and long winter nights offer advantages for testing robotic telescope technology for use in the Canadian Arctic where observing conditions have been demonstrated to often be superb. Advocates of these telescopes argue that new, small, fully autonomous telescopes should and must be built and operated in Canada to control cost and maximize efficiency.

3. INSTRUMENT DEVELOPMENT ON SMALL TELESCOPES

The world-renowned expertise in instrument development of NRC-HIA and LAE (UdeM/ULaval)[2] staff owes much of its heritage to the development of instrumentation for the DAO and OMM telescopes. Today, these facilities still act as test beds for novel instrument and technology development. Samples of work recently carried out or anticipated in the future are outlined below.

3.1. *DAO Instrument Development*

VOLT was developed for the DAO 1.2m telescope to demonstrate open loop control. This successful experiment was the basis of an MSc project at UVic and performed open loop control both on the sky (in the coudé room of the 1.2 m) and in the lab using a simple on-axis natural guide star. The experiment was also used to introduce and validate new techniques for aligning and calibrating open loop AO systems. This experience will help in the development of future Multi-Object Adaptive Optics (MOAO) instruments.

HIAC, an electron multiplication CCD imager developed by HIA staff and a McMaster U. PhD student, enables readout of images at a rate of 20 Hz and higher. Approximately 50 nights were scheduled on the 1.8 m to test the instrument and search for brief diffraction affects caused by the occultation of stars by small km-sized KBO's. The camera was also used by the VOLT team.

A circular polarization module for the Plaskett telescope was constructed for a remarkably modest hardware cost of $5K, including spare components. This device is now producing longitudinal magnetic field measurements with precision as good as or better than those measured on larger facilities (e.g., the 2 m Bernard Lyot telescope; see Fig. 5) and has led to the execution of large programs on the 1.8 m telescope in support of the CFHT Large Program MiMeS.

On the 1.2 m telescope, development effort has concentrated on enabling robotic operation of the telescope and spectrograph. Approximately 30% of the scheduled time is now being carried out robotically. Some samples of acquired data are shown in Fig. 6.

Development of a fiber-fed IFU for the Herzberg spectrograph is anticipated on the 1.8 m telescope and could pave the way to eventual robotic operation of the Plaskett telescope. HIA staff are keen to use this as an opportunity to develop in-house expertise with fiber optics.

3.2. *OMM Instrument Development*

The instrument development within the LAE helps support the OMM but also provides instruments to international partners. The LAE is one of the most important groups of this kind in Canada. A major upgrade of the OMM was made possible by a CFI/Québec/5 other partners grant for $4.7M in 1999 and led to improvements to the dome (ventilation) and the telescope, provided a fiber optic link with the university network, and three new instruments – FANTOMM, SIMON, and CPAPIR. Graduate students were/are also involved in some of these projects. Some of the expertise and major achievements of the LAE are in differential imaging (see Fig. 3), hyperspectral imaging (SpIOMM) (see Fig. 4), photon counting cameras and polarimetry. The most sensitive camera was built in 2009 by a student for his PhD at UdeM[3].

The LAE has built or contributed to instruments for the CFHT (CFHTIR, WIRCAM) and is currently

[1] http://onemetreinitiative.com/

[2] McGill is also involved in the LAE, but not in the optical/NIR.

[3] A copy of this camera has been ordered by NASA

participating in instrument development for Gemini (GPI), the JWST (fine-guidance sensor), and the CFHT (SITELLE). In many projects the tandem of OMM and LAE has provided both a test bed and a great training experience. See the WP on experimental astrophysics for details.

4. RESEARCH ON SMALL TELESCOPES

Some recent highlights of research programs completed on small telescopes are summarized in Table 3. These projects cover virtually all areas of modern astronomy and many make use of the advantages smaller facilities offer. This includes quarterly scheduling which enables rapid response to newly discovered phenomena, time for novel but high-risk programs to test new equipment or new observational techniques (such as the direct detection of extrasolar planets), very long runs of 30 consecutive nights or more, as well as weekly, monthly or longer monitoring programs over many years.

Small telescopes are also of critical importance for training students the skills required for "real" observing. In recent years an average of 8 programs carried out on the DAO telescopes each year have involved thesis projects. At OMM, an average of 12 M.Sc./Ph.D. projects, some of them partly instrumental, are carried out each year. One prominent example at the DAO is the PSSS being conducted by UVic graduate students on the 1.8 m telescope under the expert guidance of Dave Balam. This program has been wildly successful in the past few years by generating more than two dozen IAU telegrams concerning the timely spectroscopic and/or photometric confirmation and typing of extragalactic SNe and novae (Fig. 7). It has also been a morale booster for graduate students who had expressed frustration about the lack of practical, hands-on telescope experience in the modern age of large-scale surveys where the only people who really worked with telescopes were staff astronomers and technicians.

A number of regular observers at the DAO and OMM work at teaching-focused undergraduate universities or have limited research funds (postdocs) at their disposal. Having access to small telescopes that suit their research needs (scientifically and financially) are important to them, and are ideal for involving undergraduate students in publishable research.

Numerous studies have suggested that well-supported, well-instrumented small telescopes are very competitive with much larger facilities when costs per citation are taken into account (e.g. Weaver 2003). Benn & Sánchez (2001) find that the impact of individual ground-based optical telescopes is proportional to collecting area and approximately proportional to capital cost. Superbly specialized, equipped and managed small telescopes can have tremendous science impact. For example, the telescope with the highest citation record is the 2.5-m SDSS telescope.

5. PUBLIC OUTREACH

As demonstrated by IYA2009 activities, even very small telescopes play a critical part in EPO activities in Canada and throughout the world. The Plaskett Telescope assumed a much more prominent role in EPO activities in Victoria with the development of HIA's CU. Recognizing that it is the centerpiece of their displays, the Plaskett telescope is made available for CU public tours until 11 PM several nights each week between May and September. To the general public the DAO 1.8 m remains an impressive, "big" telescope that performs diverse, interesting research.

OMM, thanks to its many graduate students, has published a calendar based on data collected at the observatory since 2000. Initially in French only, it is now in both official languages to acknowledge the venue of McGill as part of the CRAQ. It is in great demand after talks in schools and MPs in both governments (Québec and Canada) also appreciate it. However, most of the public outreach is done at the ASTROLab, open every day from mid-May until the end of September, and on rendezvous during the school year, with approximately 18 000 visitors per year. ASTROLab holds many special activities every year, such as the "Festival d'astronomie du Mont-Mégantic", the Perseids, a week-end for amateur astronomers, etc. The OMM is accessible to the public (every Saturday night during the summer of IYA) and also the OPMM which houses a 0.6 m telescope. There is now a "dark sky preserve" around the OMM, the first in the world, which makes a big difference for dark sky objects. The population enthusiastically supported this project and also voiced clear support for the OMM when the NSERC MRS grant was cut in the spring of 2009.

6. CHALLENGES FOR SMALL CANADIAN TELESCOPES

The recent demise of the UWO 1.2 m telescope, operational concerns for the OMM and, perhaps to a lesser extent, the closing of the DDO make it clear that current funding levels for such facilities is the biggest challenge they face today. This paper demonstrates the high return in scientific research and EPO that can be realized from extremely modest investments in facilities based on Canadian soil where taxpayers can interact with the users.

The LRP2000 recommended that $100K/year be provided to support the enhanced operation of the DAO telescopes through 2015, the smallest item they in fact considered. The HIA was able to allocate $50K/year towards the enhanced support of the DAO telescopes until FY08/09. Through careful management and leveraging, this produced the notable improvement in scientific output and impact of the telescopes noted above (Fig. 1). Unfortunately, curtailment of LRP funds in the last two years is now impacting attempts to meet the LRP2000 mandate to enhance the operation of the DAO telescopes. LRP funds were critical to enable robotic operation of the 1.2 m telescope and assist with instrument development for the 1.8 m telescope. Including LRP2000 funds, the DAO telescopes together are operated at a cost of approximately $300K/year; this includes only one technical officer devoted full time to support of the telescopes.

A large portion of the operating costs for OMM/LAE came from NSERC until the spring 2009 when NSERC did not renew the $325K/yr MRS grant on the basis that OMM/LAE is not a "national" facility. After a huge public outcry the Government of Canada managed to find non-NSERC money to keep the OMM operating until 31 March 2011. Obviously the plan for the future is to maintain operation and development of the OMM, but this will be difficult without a contribution from NSERC. The next two years will be critical: the UWO 1.2 m telescope closed because of a similar loss of NSERC funds.

On a positive note, in 2009 June the OMM/LAE received a CFI/Québec grant of $11.7M to upgrade the observatory with new equipment and instrumentation.

7. RECOMMENDATIONS

This WP demonstrates the value of continuing, and preferably augmenting, support for small telescopes throughout the country. Other nations agree: for example, France's recent investment in the development of the NARVAL spectropolarimeter for the 2 m telescope at Pic du Midi has made it one of the top facilities in the world for observational studies of stellar magnetism.

Large investments have been made in the construction of telescopes at sites such as the DAO, the OMM and the RAO, and continue to be made for new instrument development at OMM. Their operational costs are, when compared to larger offshore facilities, extremely modest, they continue to be very productive scientifically, and they show an increased level of productivity when their operational funding is augmented.

To ensure a healthy national astronomy program, Canadian astronomers must be provided access to a full range of facilities and so our small telescopes must be assured of adequate operations and development support. We therefore make the following recommendations:

- We recommend that a mechanism be found (such as was provided previously by NSERC MRS grants) to allow university facilities such as OMM/LAE and RAO to receive, through rigorous peer review, funding for their operation and development to enable them to continue to fulfill their important roles to the Canadian astronomical community outlined in this document. This is particularly urgent in light of the recent CFI grant of $11.7M for OMM upgrades and the lack of operational funding support beyond 31 March 2011. Secure, long-term operational funds are needed to enable the benefits of this large CFI investment to be fully realized by Canadian astronomers.

- We recommend funding of the DAO telescopes at a level of at least $100K/year (i.e., the level recommended in LRP2000) to enable continued enhancement of their operation and productivity. This will enable provision of a modest level of service observing support for the 1.8 m telescope to encourage new large programs, help fund the scanning and secure storage of the historical DAO plate archive while on-site expertise remains available at the HIA, enable completion of an on-line archive for approximately two decades of DAO CCD and Reticon data through facilities provided by the CADC, assist with the procurement of new CCD's and maintenance of current hardware to improve reliability and productivity, and encourage development of an IFU unit for the Herzberg spectrograph to enable future automation of the 1.8 m telescope.

- We encourage additional support for the development of small, modern, robotic telescopes at superb sites within Canada. In particular, the placement of such a facility in the Canadian Arctic would be of particular interest as a site testing facility for a possible future large Arctic telescope in light of recent demonstrations of the superb seeing conditions inherent to some northern sites. Similarly, the One-meter Initiative, with its new technology, would be very competitive.

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TABLE 1
Acronyms used in the text.

Acronym	Description
AGN	Active Galactic Nuclei
Ap/Bp stars	Chemically peculiar A (and B) stars
ARCT	A. R. Cross Telescope
AURT	Athabasca University Robotic Telescope
CPAPIR	Caméra PAnoramique pour le Proche InfraRouge (wide-field NIR imager)
CFHT	Canada-France-Hawaii Telescope
CFHTIR	Infared camera for CFHT
CRAQ	Centre de recherche en astrophysique du Québec
CU	NRC's Centre of the Universe
DAO	Dominion Astrophysical Observatory
DDO	David Dunlap Observatory
EPO	Education and Public Outreach
FANTOMM	Fabry-Perot intermeter for OMM
FTE	Full-time equivalent
FY	Fiscal Year
GC	Globular cluster
GPI	Gemini Planet Imager
HIA	Herzberg Institute of Astrophysics
HIAC	HIgh-speed Acquisition Camera (in Chinook jargon, "hyak" means fast)
HQP	Highly-qualified Personnel
IFU	Integral field Unit
IR	Infrared
ISM	Interstellar Medium
IYA	International Year of Astronomy (2009)
JWST	James Webb Space Telescope
LAE	Laboratoire d'astrophysique expérimentale
LRP	Long Range Plan
MiMeS	Magnetism in Massive Stars (CFHT Large Program)
MOST	Microvariability and Oscillations of Stars Space Telescope
MRS	NSERC's Major Resources Support grants
NIR	Near-infrared
NRC	National Research Council of Canada
NSERC	National Science and Engineering Research Council
OMM	Observatoire du Mont-Mégantic
OPMM	Observatoire Populaire du Mont-Mégantic
PAGB	Post-asymptotic giant branch
RAO	Rothney Astrophysical Observatory
RV	Radial Velocity/Rendez-Vous
SIMON	Spectrographe Infrarouge de MONtréal (also imager with polarimetry)
SIMP	Sondage infrarouge de mouvement propre
SITELLE	Spectromètre Imageur à Transformée de Fourier pour l'Etude en Long et en Large de raies d'Emission – for CFHT
SN(e)	Supernova(e)
SpIOMM	Visible Imaging FTS for OMM
UdeM	Université de Montréal
ULaval	Université Laval
UofC	University of Calgary
VOLT	Victoria Open Loop Testbed
WIRCAM	Wide-InfraRed CAMera for CFHT
WP	White Paper

TABLE 2
Small Canadian ground-based optical and infrared telescopes.

Name	Aperture (m)	Dates	Location
Plaskett	1.83	1918 -	DAO, Victoria, BC
RAO	1.8	1995 -	Calgary, AB
OMM	1.6	1978 -	Mont-Mégantic, QC
DAO 1.2 m	1.2	1962 -	DAO, Victoria, BC
New Univ. of Victoria Observatory	0.80	2010 -	Victoria, BC
OPMM	0.61	1998 -	Mont-Mégantic, QC
Argentina/Univ. of Toronto	0.60[%]	2007 -	El Leoncito, Argentina
York Univ. Observatory	0.60 & 0.40[$$]	1968 -	Toronto, ON
Climenhaga Observatory	0.50	1976 -	Victoria, BC
Baker-Nunn	0.50	2002 -	Calgary, AB
UBC Observatory	0.42	≈1981	Vancouver, BC
Burke-Gaffney	0.41	1972 -	Halifax, NS
Clarke-Milone	0.40	1972 -	Calgary, AB
AURT	0.40	2009 -	Athabasca, AB
Observatoire du Mont Cosmos	0.40[&]	1965 -	ULaval, Saint-Elzéar-de-Beauce, QC
Sleaford Observatory	0.40 & 0.30	1998 -	Saskatoon, SK
Abbey Ridge	0.28	2006 -	Halifax, NS
Hume Cronyn Memorial Obs.	0.25* & 0.30	1940 -	London, ON
U. of Saskatchewan Campus Obs.	0.15*	1930 -	Saskatoon, SK
David Dunlap Observatory	1.88	1935 - 2008	Richmond Hill, ON
Elginfield Observatory	1.2	1969 - 2010	London, ON
Univ, of Toronto	0.60[#]	1971 - 1997	Las Campanas, Chile
Devon Observatory	0.5		Devon, AB

Notes: * refractor. [%] UofT has 25% of the time, Argentina pays for operation expenses. [#]This telescope has been used for research in Chile, later moved to Argentina, as listed above. [&] The telescope was replaced in 2006 by another one with the same diameter. [$$] The 0.40 m telescope replaced a 0.30 m telescope in 1999.

TABLE 3
Highlights of Research Programs Carried out on Small Telescopes.

Telescope	Summary	Reference
DAO 1.2 m	Discovery of "weather" in the atmosphere of a peculiar HgMn star, the first secular variations seen in a chemically peculiar star. This is attributed to a non-equilibrium, dynamical evolution of heavy-element clouds createdby atomic diffusion, and may have the same underlying physics as the weather patterns on terrestrial and giant planets.	Kochukhov et al. (2007)
DAO 1.2 m	Spectra of the narrow 5450Å diffuse interstellar band with a S/N of 1200:1 were obtained and demonstrated to have a very close coincidence in both wavelength and band shape with a molecular feature appearing consistently in an expanded acetylene plasma produced in the lab, suggesting for the first time a credible explanation for one of the mysterious DIBs.	Linnartz et al. (2010)
DAO 1.8 m	Imaging data for a PhD thesis provided a new, large sample of SDSS secondary photometric standard stars. This program made use of new SDSS filters acquiredusing LRP2000 funds and an allocation of 130 nights of telescope time.	Clem et al. (2007)
DAO 1.8 m	An HIA Plaskett Fellow used 36 of 40 consecutive nights to provide a critical extension of an international multi-site reverberation mapping observing campaign for several bright AGN to constrain the nature of black holes in the centers of galaxies.	Denney et al. (2009)
DAO 1.8 m	The Plaskett Spectroscopic Supernovae Survey (PSSS) typically uses two nights per week to spectroscopically classify new SNe and transient objects and to build a database of supernova spectra (see Fig. 7)	Hsiao et al. (2010)
DAO 1.8 m	Potentially hazardous asteroids are monitored on a monthly basis as part of a long-term target-of-opportunity program with the Newtonian imager. A very recent result is shown in Fig. 8. This could be a prominent key program on the 1.8 m telescope if funding for a modest level of observing support were available.	Many MPC/IAUC
OMM	Spectroscopic variability of massive stars; new candidates presenting variability that potentially comes from corotating interaction regions have been found; followup studies to identify periods would yield estimates of their rotation rate	St-Louis et al. (2009)
OMM	Polarimetric variability of pre-main-sequence spectroscopic binary stars; 90% of those binaries are polarimetric variables and 2 showed phase-locked variations. Non-periodic stochastic events prevent finding the orbital inclination. About 400 nights of telescope time over 5 years were assigned for this project and yielded 1 PhD thesis and 5 papers	Manset & Bastien (2003)
OMM and CTIO	Sondage infrarouge de mouvement propre (SIMP); infrared proper motion survey with CPAPIR to identify brown dwarf stars; the light curves of the brightest T2.5 brown dwarf found show a periodic modulation with a period of $\sim$ 2.4 hr, a peak-to-peak amplitude of 50 mmag and significant, night-to-night evolution providing evidence for evolving weather patterns	Artigau et al. (2009)
CTIO 1.5 m + CPAPIR OMM	Wolf-Rayet survey and spectroscopic follow-ups with SIMON at OMM; 41 new WR stars, 15 of type WN and 26 of type WC have been found via a new J, K, and narrow-band imaging survey of 300 deg^2 of the plane of the Galaxy	Shara et al. (2009)
OMM	Studies of old galactic HII regions; an Hα investigation, with the Fabry-Perot interferometer FaNTOmM, of the tenuous ionized material found embedded in the northern portion of W4 revealed the kinematic signature is expected from the chimney model; the dynamical age of the W4 chimney is estimated at 4.1 Myr	Lagrois & Joncas (2009)
OMM	An Hα follow-up survey of the Spitzer Infrared Nearby Galaxies Survey (SINGS) sample reveals that non-circular motions associated with galactic bars affect the kinematical parameters and the velocity gradient of the rotation curves. This leads to incorrect determinations of the baryonic and dark matter distributions in the mass models derived from those rotation curves	Dicaire et al. (2008)

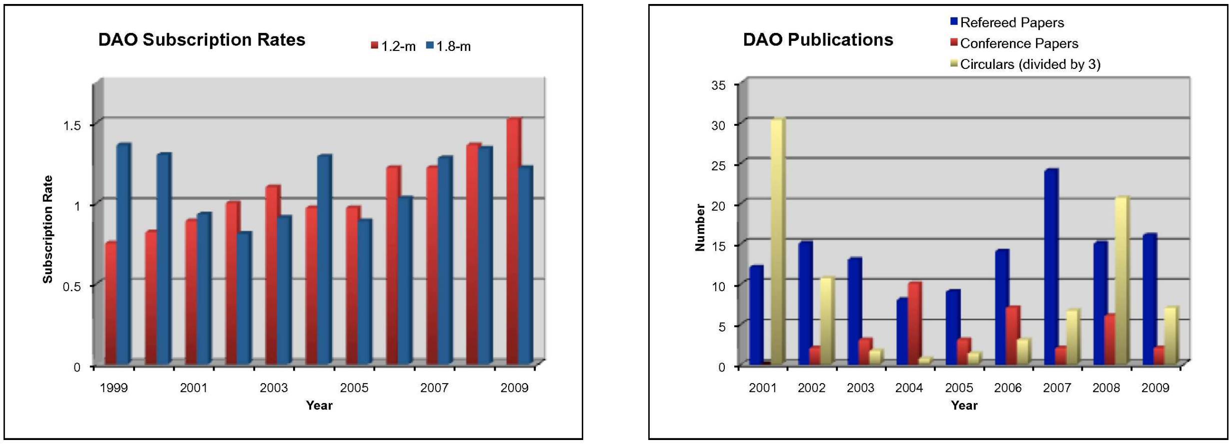

FIG. 1.— (Left) The subscription rates for the DAO 1.2 m and 1.8 m telescopes for the last decade. Increase in demand for time at DAO in the early 2000's coincided with the availability of a modest level of LRP2000 support. (Right) Publication statistics for the DAO 1.2 m and 1.8 m telescopes for the last decade. We suggest that increased scientific productivity of the two telescopes was also a result of improved technical support possible because of modest LRP2000 funds.

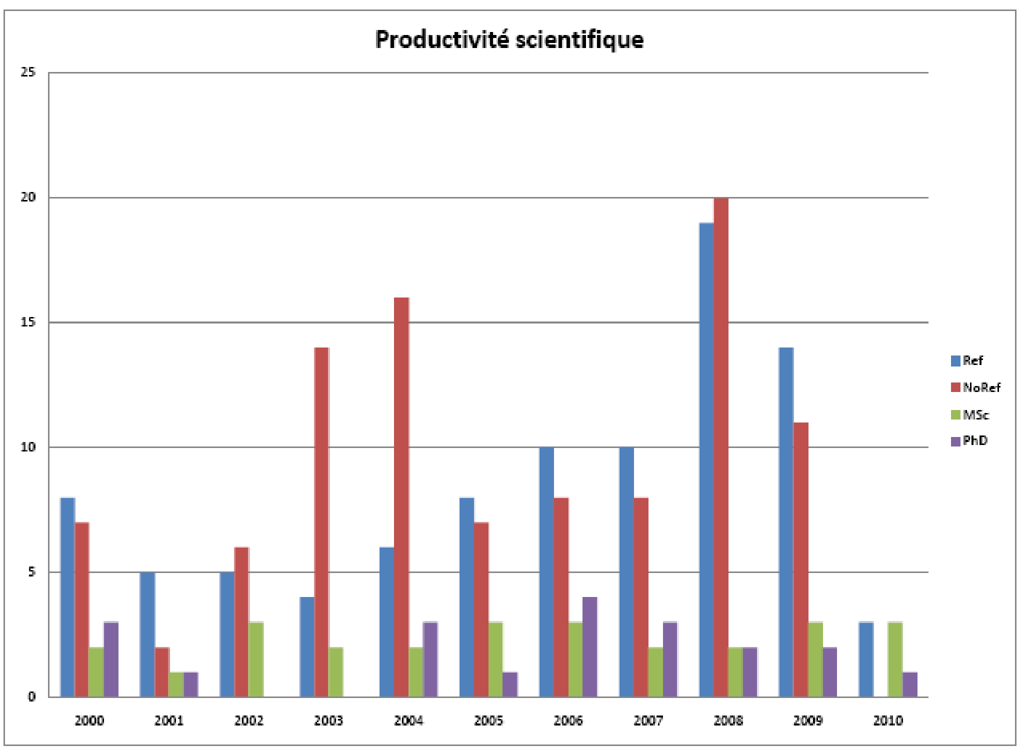

FIG. 2.— Scientific productivity of the OMM/LAE during the period 2000-2010 counted as the number of refereed, non refereed papers, and M. Sc. and Ph. D. theses. We notice an increased scientific productivity following the major CFI upgrade in 1999-2003.

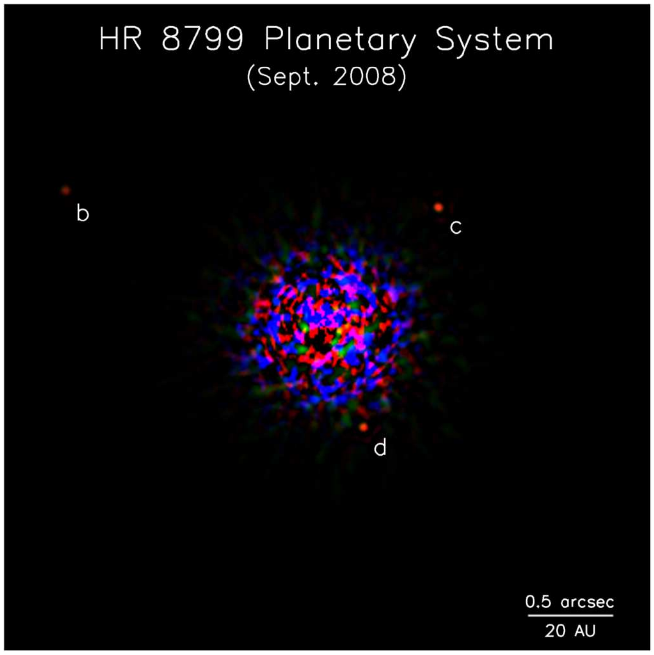

FIG. 3.— The first image of a planetary system, found with Gemini (Marois et al. 2008). It is the end result of a long quest starting with differential imaging in wavelength (OMM and CFHT) and then in angular spatial direction (Gemini and Keck). Ground-based telescopes and MOST have been instrumental for determining an age of the primary through lengthy photometric and spectroscopic campaigns.

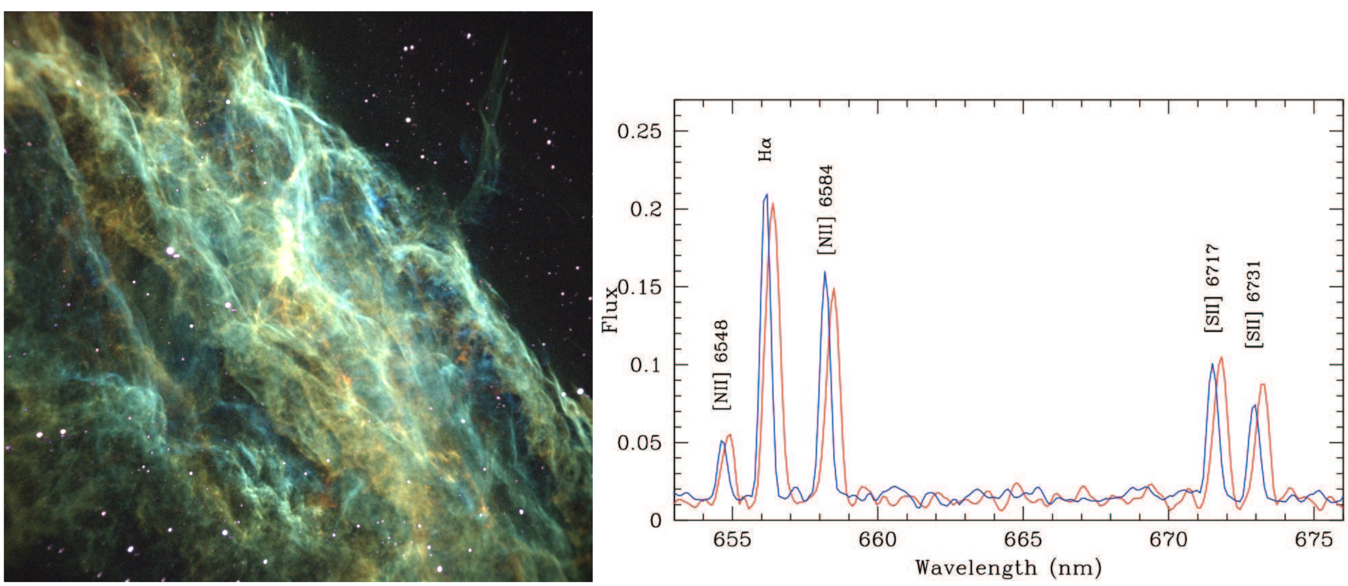

FIG. 4.— Example of data obtained with SpIOMM at the OMM: (left) Velocity map of a small section (12′× 12′) of the supernova remnant NGC 6992 (part of the Cygnus Loop), derived from all the lines available in a red data cube: [NII] λ6548, Hα, [NII] λ6584, [SII] λ6717 and [SII] λ6731. Velocities range from -65 km/s (coded as blue) to +60 km/s (coded as red). The data cube is composed of 1.7 million spectra spanning the 650 - 680 nm range, with a resolution of 0.3 nm. (right) Spectra of two filaments in NGC 6992 (average of 5 pixels each) with different velocities, extracted from the same cube. Figure provided by L. Drissen.

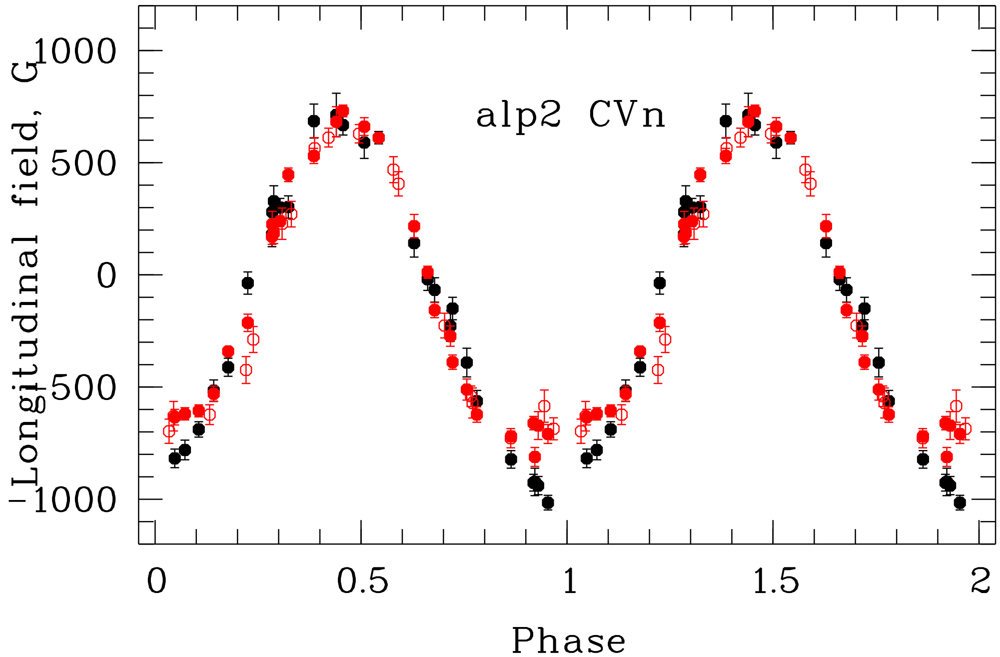

FIG. 5.— Magnetic field observations of the magnetic Ap star α^2 CVn. Solid black points are measurements derived from only the Hβ line with the new DAO polarimeter on the 1.8 m telescope. Solid red points are also DAO measurements derived from the single Fe II λ4923 line. Open red points were obtained with the MuSiCoS spectrograph on the 2 m Bernard Lyot telescope but were derived from an average of many metallic lines (Wade et al. 2000). Exposure times on both telescopes were typically about 20 minutes. Note the different magnetic field strength measured with the Hβ line versus the Fe II line; this is real and is likely caused by the non-uniform distribution of iron over the surface of the star. Measuring such differences is a unique capability provided by the DAO polarimeter.

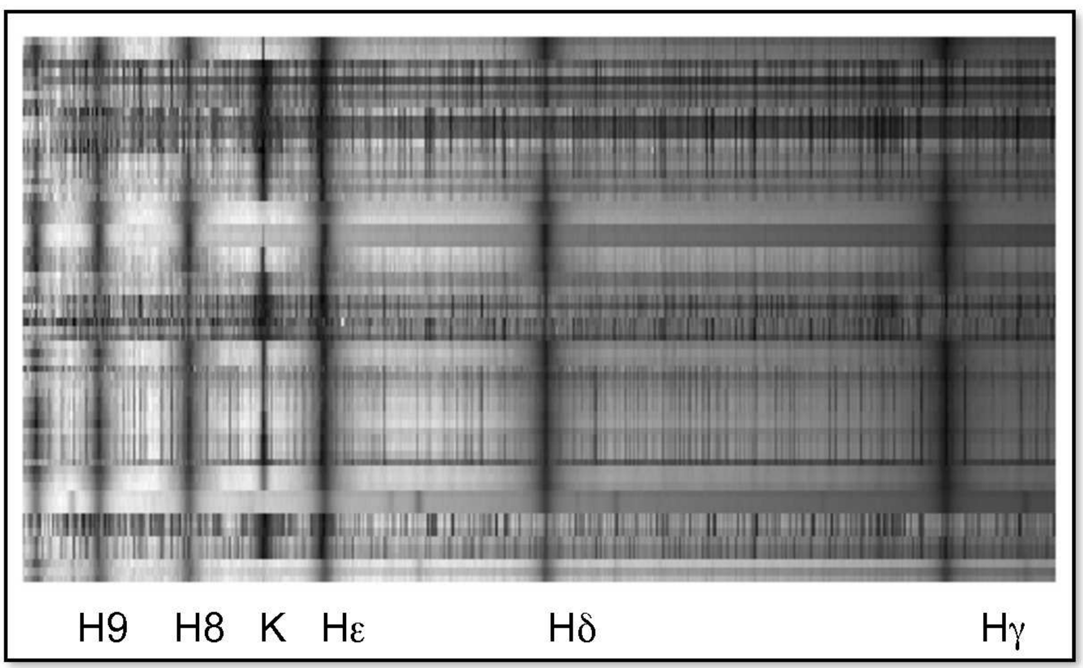

FIG. 6.— 70 moderate-resolution spectra of 24 stars obtained during one night of unattended robotic observing with the DAO 1.2 m telescope. Each row in the image is an individual spectrum. The magnitude range of the stars shown is V = 5 to 8 and the system is capable of acquiring stars as faint as V = 12.

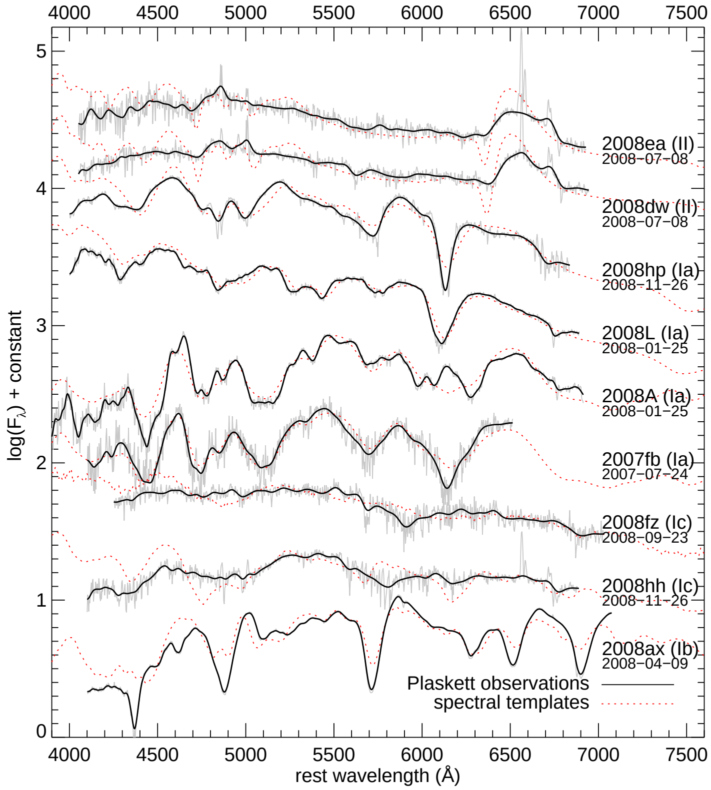

FIG. 7.— Sample SNe spectra obtained on the DAO 1.8 m telescope by UVic graduate students as part of the large PSSS. Object magnitudes are typically V=16 or 17 but objects to V=18 have been observed. For more information see http://supernova.lbl.gov/∼hsiao/psss.

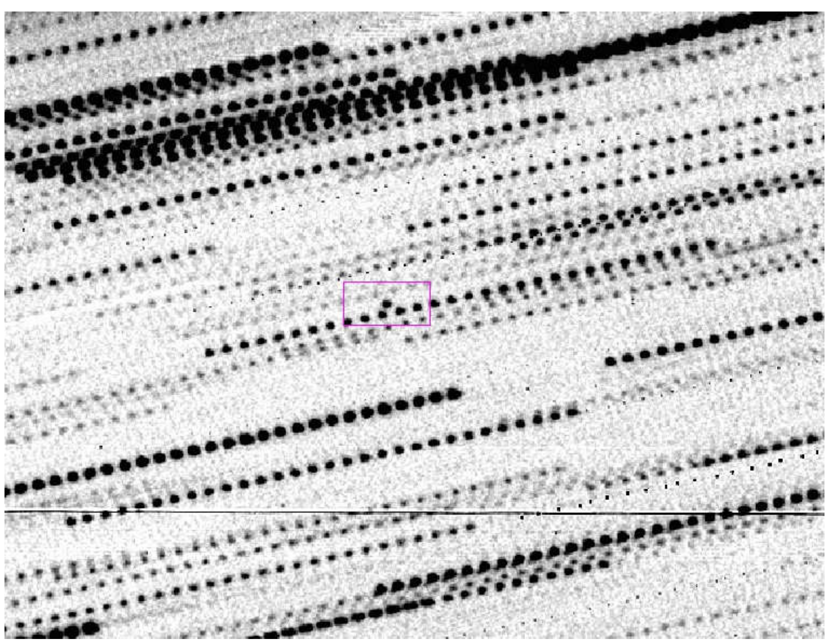

FIG. 8.— An image of the asteroid 2002 XY38 (inside the box) obtained with the DAO 1.8 m telescope on 15 Feb 2010 (UT). This is a probable Earth impactor in the 15-25 m diameter range (i.e., corresponding to a 5 - 10 Mton airburst) and has been scheduled for immediate radar Doppler data acquisition at Arecibo. In order for the radar observations to take place the object's orbit must be refined via optical astrometry in the last few days before Arecibo observations begin. The image consists of a stack of $30 \times 10\,$s exposures shift and added on the rate of motion of the asteroid. The asteroid is currently moving through the star field at 10 minutes of arc per hour and speeding up considerably. Image courtesy of Dave Balam.