

National Research Council of Canada
Herzberg Institute of Astrophysics
Optical Astronomy Program
Dominion Astrophysical Observatory
5071 West Saanich Road, Victoria, British Columbia, Canada V9E 2E7

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This report covers the period from 1999 April 1 through 2000 March 31, while the publications are for the calendar year 1999.

1. HIGHLIGHTS

Van den Bergh completed his monograph, *The Galaxies of the Local Group*, which is being published by Cambridge University Press in 2000.

A systematic search begun for faint emission lines indicative of recent star formation in all the bright galaxies in the low-density regions of the Updated Zwicky Catalogue detected 17 new minor-merger pairs.

While the luminosity function shape and turnover level for the globular cluster system of NGC 4874 in the Coma Cluster of galaxies are normal, other properties suggest that no single one of the classic modes of galaxy formation (accretion, disk mergers, *in situ* formation) can supply a fully satisfactory picture.

From analysis of UBV colours and H α fluxes for a moderate-sized sample of isolated dwarf irregular galaxies, the majority of these galaxies do not have a starburst phase.

The Far Ultraviolet Spectroscopic Explorer (FUSE) satellite was launched on 1999 June 24, after two decades of planning and construction. Canada's hardware contribution to the mission, the Fine Error Sensors (FES) and software, were developed by ComDev International with significant HIA involvement.

The optical barrels and the prefocal assembly for the first Gemini Multi-Object Spectrograph (GMOS) were completed and delivered to the Astronomy Technology Centre, Edinburgh, for integration and testing. Construction of Altair, the natural guide star adaptive optics system for Gemini, commenced.

An application for the two-layer antireflection coating used on the GMOS optics was accepted by the U.S. Patent Office.

Hesser received awards from the University of Buenos Aires and the University of Kansas.

2. STAFF

On 2000 March 31 the staff responsible to J. E. Hesser, Director of Optical Astronomy, comprised four groups.

Optical Instrumentation: D. Crampton (Group Leader), A. Anthony, D. R. Dardall, D. R. Duncan, J. Dunn, S. M. Dzbik, A. Ebberts, E. Eisenhuth, J. T. Fitzsimmons, J. M. Fletcher, C. Ganton, T. Hardy, G. Herriot, G. D. Hnylycia, J. W. Jennings, D. C. Josephson, B. M. Leckie, C. L. Morbey,

R. G. Murowinski, S. Roberts, L. K. Saddlemyer, J. F. Sebesta, P. Shott, M. Smith, D. J. Stajduhar, J. R. Stilburn, K. E. Szeto, J.-P. Véran, and R. M. Wooff.

Canadian Astronomy Data Centre: D. Durand (Group Leader), D. A. Bohlender, P. D. Dowler, S. J. Gaudet, N. R. Hill, S. Jaeger, and D. Schade.

Computer Group: P. B. Stetson (Group Leader), G. Berry, G. A. Justice, J. Ouellette, E. V. Sullivan, and R. A. Walker.

Reporting directly: E. J. Barton (RA), J. P. Fulbright (RA), J. B. Hutchings, S. L. Morris, L. van Zee (RA), and D. R. Bond.

During the year there were three Women in Engineering and Science (WES) students, D. Frenette, I. Jean, and S. Juneau, and four co-op students, A. Drew and R. Gaunt (U. Victoria), and A. Hill and K. Taylor (Camosun College).

Secondments brought G. Siddall from the Canadian Federal Department of Fisheries and Oceans and W. Windels and M. Pflieger from Automation Systems Associates Ltd. of Sidney, B.C.

F. Richardson M. of CONICYT, Chile, visited the Canadian Astronomy Data Centre to initiate the Phase One activities of the Gemini Science Archive.

Sabbatical visits from Israel brought M. Raviv of HI-Tec Solutions OCR Systems to the Canadian Astronomy Data Centre and M. Raviv to the Optical Instrumentation Group.

Research studies and other interactions were undertaken at DAO by dozens of other researchers from around the world in the course of the year.

G. Broom, S. Courteau (RA), T. Hare, T. Lavezzi (RA), W. Rambold, E. Steinbring, and R. Zingle left HIA during the reporting period.

C. G. Aikman (Seameadow Astronomics Inc.), A. H. Batten, R. D. McClure, B. Oke, S. van den Bergh, and F. P. Younger continued as guest workers at the Observatory for the full year.

3. SCIENTIFIC RESEARCH

3.1 Cosmology

Crampton, Lilly (U. Toronto) and LeFevre (LAM, Marseille) continued work on deep UBVI imaging data from the CFHT UH8K camera of four 0.5-deg fields centered on CFRS fields. U. Victoria student Swerdlyk, U. Toronto student Brodwin, and LAM research associate McCracken have completed much of the data reduction and are beginning various astronomical projects with the data.

Courteau organized a technical workshop for 90 specialists on Cosmic Velocity Fields held at U. Victoria on 1999 July 13–17. Support was provided in part by the Canadian Institute for Theoretical Astrophysics. Courteau obtained his first major "Shellflow" results during his last months at HIA and presented them at the workshop. These include the find-

ing that the flow of galaxies at 6000 km s^{-1} is nearly at rest with respect to the cosmic microwave background. This result provides strong support for low-amplitude, coherent flows in the Universe, in perfect agreement with current models of cosmological structure formation.

The CNOC2 project, led by Ray Carlberg (U. Toronto) and including Simon Morris, reached the end of the data collection phase in 1998 May. The data are now fully reduced yielding 6000 galaxies with redshifts between 0.2 and 0.6 in four patches on the sky. A full analysis by Ray Carlberg (U. Toronto) of correlation amplitude evolution from the four patches on the sky is in press, along with a data paper describing the observations and reductions. Morris is using these data (along with new observations obtained in 1999 August at CFHT in $H\alpha$ to calculate the evolution in the star formation density (solar masses per cubic megaparsec) as a function of redshift.

The Hubble Space Telescope Key Project on the Extragalactic Distance Scale, in which Stetson has played a major role, is winding down. All observations for the project have ceased, and eight additional papers in the series were published during 1999. These papers yielded Cepheid-based distances to NGC 4725, 3198, 1365, 4548, 4535, 3319, and 1326A, and one of the papers discussed the implications of the new distance to the Fornax galaxy cluster. Stetson also contributed to another paper, independent of the Key Project, which estimated a Cepheid distance to the galaxy NGC 4603.

3.2 QSOs & Active Galaxies

Hutchings worked with Crampton and Morris observing high-redshift QSOs at CFHT using the AO system in broad-band visible light in 1999 March and in narrow-band IR radiation (to isolate redshifted emission lines) in 2000 January. The runs were successful and data on a sample of objects are being analyzed. There is resolved structure and data on companions, but the statistical results are not yet complete.

Hutchings, with Hanisch (STScI), Redding (JPL), and Neff (GSFC), is analyzing data from a recently completed cycle 6 HST program to image high-redshift QSOs. Detailed PSF modeling is being done, but the data already indicate resolved structure in most of the objects observed. Hutchings and U. Victoria student Koppin are analyzing Space Telescope Imaging Spectrograph (STIS) images. Spectra have been obtained of a merging, low-redshift QSO, to reveal the stellar populations and dynamics of the system.

Hutchings, with Kinney and Schmitt (STScI), obtained narrow-band images of redshifted $H\alpha$ and [O III] in several Seyferts from an unbiased sample, using the CFHT Adaptive Optics Bonnette (AOB) camera. These are being compared with VLA radio images of the sample to determine the statistics of the nuclear engine orientation in AGN. A further program of imaging with HST has been approved for cycle 9.

Hutchings leads a STIS team program investigating the Seyfert NGC 4151. The new data include long-slit spectra across the broad-line region, UV echelle spectra of the nucleus, linear ramp filter images in line emission wave-

lengths, and monitoring of UV line profiles for changes. Several papers have been completed. Collaborators are Kaiser (Johns Hopkins U.), Weistrop and Nelson (U. Nevada), Kraemer and Crenshaw (GSFC).

Final observations have been obtained in the STIS team program, led by Hutchings, investigating jets in 3C sources with long-slit spectroscopy. These reveal different conditions among the sample objects, from synchrotron jets to biconical outflows. Collaborators are Kaiser (Johns Hopkins U.), Baum (STScI), and Gelderman (U. Kentucky).

Several papers describing AOB observations of Seyfert galaxies are now in press from Chapman (U. British Columbia) and Morris.

Morris continues a monitoring campaign on Seyfert galaxies with Penfold (Mt. Royal College) using DAO's 1.8-m Plaskett Telescope.

3.3 Galaxies

A large number of papers have been published by Balogh (U. Victoria) and Morris exploiting the data from the CNOC1 project (primarily aimed at studying the mass density of the universe, using observations of rich clusters of galaxies). Balogh (co-supervised by Morris) successfully defended his Ph.D. thesis on this work.

Barton, in collaboration with Kannappan, Kurtz, and Geller of the Center for Astrophysics (CfA), completed a paper on the reduction of long-slit rotation curves with cross-correlation techniques. They showed that cross-correlation errors accurately reflect the presence of multiple velocity components; thus, the technique can be used to flag complex velocity structure for further study.

Barton, in collaboration with Geller (CfA), finished analysis of the Tully-Fisher properties of a sample of galaxies in pairs using optical rotation curves. Surprisingly, they found that almost all of the interacting galaxies lie on a Tully-Fisher relation very similar to that of field galaxies, often in spite of substantial star formation and/or tidal distortion. Four notable exceptions appear overly luminous for their measured emission-line widths. They are relatively low-luminosity galaxies ($M_B \sim -18$) with substantial central star formation. Barton and van Zee used archival VLA data to show that, in at least one case, the true kinematic line width is much larger ($\geq 2\times$) than the apparent emission line width, because the emission-line flux does not extend past the center of the galaxy. These low-redshift galaxies appear to be counterparts to high-redshift galaxies with anomalous narrow emission lines. If they are, the result of Barton and van Zee suggests that the anomalous high-redshift galaxies are really spiral galaxies forming bulges, rather than bursting dwarfs (as was previously thought).

In order to explore the amount and spatial distribution of the interaction-induced star formation, Barton observed a carefully selected subset of galaxies in pairs with OSIS-V at CFHT. The lumpy star-forming structures that appear off-center in the galaxies suggest that the new stars formed from the interaction may be adding to the luminosities of the bulges in the progenitor galaxies.

Barton began a large collaboration with Geller *et al.* at the CfA to search systematically all the bright galaxies in the

low-density regions of the Updated Zwicky Catalogue for minor companions, and to remeasure the spectra of some galaxies in known pairs in order to detect faint emission lines. By fiscal-year end, 97 observations had been completed at the 1.5-m telescope on Mt. Hopkins, resulting in, among other things, the detection of 17 new minor pairs.

Courteau expanded his research on the structure of spiral galaxies with new research programs on stellar populations, dust, and the distribution of dark matter through two new collaborations at Stanford and Steward Obs. The Stanford collaboration has resulted in co-advising Masters student Michael Dorris (supervised locally by Jeff Willick) on the coupling between rotation curve and dark matter distributions. Courteau also co-supervised HIA/WES student Stephanie Juneau with Morris on a project to monitor variability in AGNs.

Holland (Aarhus), P. Côté (CalTech), and Hesser published their analysis of WFPC2 V and I photometry of the inner regions of NGC 5128. Their goal was to search for globular clusters, especially ones that might have been formed during the apparent merger between the elliptical and a small, late-type spiral some 200–500 Myrs ago. Twenty-one candidates were identified, which seem to be systematically more elliptical than clusters in the Milky Way. Approximately half of the clusters have colors consistent with their being old globulars similar to those of the Milky Way, while the other half may be either old, unreddened clusters or young, reddened ones that could have formed during the merger event.

Hutchings and U. Victoria student Edwards completed stellar population studies on three CNOC1 clusters. The results show there are different stages of cluster evolution and merging in the redshift range 0.2 to 0.3. Hutchings, Schade, and Balogh (U. Victoria) are investigating the morphology of member galaxies of CNOC clusters, based on imaging data from CFHT and HST.

Hutchings has obtained HST images and spectra of the cD galaxy in Abell 2390. Together with CFHT H α data, Hutchings and Balogh (U. Victoria) showed that there is extended hydrogen and UV emission across the whole galaxy, with a possible large outflow velocity.

Hutchings is continuing HST imaging programs to study the hot stellar populations in nearby galaxies with collaborators Bianchi and Kaiser (Johns Hopkins U.). Complementary ground-based spectra are being obtained of FUSE program stars in collaboration with Robert and Pellerin (U. Laval).

Hutchings, Neff (GSFC), Kaiser (Johns Hopkins U.), and Weistrop (U. Nevada) have obtained STIS spectra of star-forming regions in NGC 4038/9 (the Antennae) and NGC 548. These are being analyzed to model their stellar populations, initial mass functions, and ages.

As part of the STIS team program on nearby galaxy dynamics, long-slit spectra of the nucleus of M33 are being analyzed by Hutchings, Joseph (Rutgers), and Green (NOAO). The implied central object mass is the lowest yet measured, and the data are also being used to understand the central stellar population and central luminous x-ray source.

Kavelaars, W. Harris (McMaster U.), Hanes (Queen's U.), Hesser, and Pritchett (U. Victoria) analyzed properties of

the globular cluster system of NGC 4874 in the Coma Cluster using deep HST/WFPC2 V- and I-band images. From the globular cluster luminosity function they deduced that $\Delta(m-M)(Coma-Virgo)=4.06\pm 0.11$ mag. They find a Hubble Constant of (69 ± 9) km s $^{-1}$ Mpc $^{-1}$. While the luminosity function shape and turnover level are normal, the globular cluster system is more spatially extended than normal, the metallicity distribution is unimodal and metal poor ([Fe/H]=−1.5), and is modestly populated, with a specific frequency of 3.7 ± 0.5 . From these properties they suggest that no single one of the classic modes of galaxy formation (accretion, disk mergers, *in-situ* formation) can supply a fully satisfactory picture.

In collaboration with Pierce (U. Indiana), van den Bergh is continuing HST observations of Cepheids in a Virgo cluster galaxy. He also reviewed the early history of the discovery of dark matter in the Universe, with special emphasis on the early work by Zwicky, Smith, Babcock, and Oort.

Van Zee has completed the analysis of UBV colors and H α fluxes for a moderate-sized sample of isolated dwarf irregular galaxies. Based on the observed colors and current star formation rates, the majority of dwarf irregular galaxies appear to undergo quasi-continuous star formation activity for their entire lifetimes. That is, the majority of dwarf irregular galaxies do not have a starburst phase.

In collaboration with Skillman (U. Minnesota) and Salzer (Wesleyan U.), van Zee obtained stellar rotation curves of a small sample of starbursting dwarf galaxies in order to determine if the stars and gas were kinematically coupled. The observations were conducted with the CFHT and with CTIO's Blanco Telescope. Preliminary analysis of the Ca triplet lines indicates that the stars are kinematically coupled to the gas, and that these objects are rotationally supported. Observations of the gas kinematics for another two galaxies from H I synthesis observations with the VLA are being analyzed.

In collaboration with Haynes (Cornell U.), van Zee obtained optical spectra of several H II regions in a sample of isolated dwarf galaxies with the Palomar 5-m telescope. The spectra will be used to determine the metallicity of these objects, and to determine if quiescent dwarf galaxies act as closed systems.

3.4 Local Group Galaxies

Bohlender and Hesser, in collaboration with Chu (U. Illinois) and Suntzeff (NOAO/CTIO) completed the editing of IAU Symposium 190, *New Views of the Magellanic Clouds*, which was published in December 1999.

Crampton and Hutchings, with Cowley and Schmidtke (Arizona State U.), have obtained further observations of x-ray sources in the LMC and southern Milky Way at the CTIO 4-m telescope. New binary orbits and identifications have been derived from photometry and spectroscopy. The same researchers have programs on supersoft sources in the LMC approved for FUSE. These will provide continuous monitoring of the far UV spectrum around the orbital cycles.

The FUSE telescope has begun to obtain data on a large, hot stellar wind project that will compare wind processes among the local galaxies. Initial data on SMC and LMC stars

show large wind differences between similar stars. Other observations reveal changes in structures in the wind, and phase-related changes in the outburst variable HD 5980. Wind models are being applied to the line profiles from the FUSE data. The program is led by Hutchings with collaborators Morton, Crowther (UCL), Fullerton and Bianchi (Johns Hopkins U.), and Massa (GSFC). Observations in M31 and M33 are still to be obtained.

Hutchings and Bianchi have obtained HST slitless spectra of a dusty OB association in M31 to derive the UV extinction curve and its variation.

Pritchett (U. Victoria) and van den Bergh have found the slope of the luminosity function of the Local Group to be -1.1 ± 0.1 , which is much flatter than that found in most rich clusters of galaxies.

Stetson participated with large teams in obtaining HST photometry for stars in the Local Group galaxy Leo I and in discovering and characterizing a unique caustic-crossing microlensing event in the Small Magellanic Cloud.

Van den Bergh finds that, at the 99% confidence level, the sub-clustering of Local Group dSph galaxies is much more pronounced than that of its dIrr galaxies. In collaboration with Fesen, van den Bergh is continuing HST observations of the expansion of the supernova remnant Cass A.

Van den Bergh wrote a comprehensive review on our present knowledge about the structure and galactic content of the Local Group of galaxies, and a review of the past, present, and future of the Magellanic Clouds.

3.5 Globular & Open Clusters

Gebhardt (U. California, Santa Cruz), Pryor, O'Connell, Williams (Rutgers U.), and Hesser completed their analysis of CFHT data for M15 obtained with an imaging Fabry-Perot interferometer and the Adaptive Optics Bonnette. Average image quality of $0.15''$ full-width at half maximum, with $0.09''$ for the best-seeing image, permitted velocity measurements for five stars within $1''$ of the cluster center. They found the same velocity dispersion of 11.5 km s^{-1} within a radius of $2''$ as they had previously measured to a radius of $6''$, but the projected net rotation velocity increases rapidly in the central regions. A central black hole of $\sim 2000 M_{\odot}$ could sustain the observed rotation amplitude and change of position angles.

In 1999 May and July Holmgren (Brandon U.) began work on a project to study early-type stars in clusters. The idea is to use spectroscopic techniques (moderate- and high-resolution spectroscopy) to define physical parameters (mass, radius, temperature) for the cluster stars and thus observationally to determine main sequences for clusters. Studies of both binary and single stars are required for this project. A number of binary systems have been observed in the clusters η Per, α Per, the Pleiades, NGC 6871, NGC 7160, and Cep OB1. All observations were made with the DAO 1.2-m telescope and coude spectrograph. So far, analyses have been performed on the binary system BD+61° 2213 in NGC 7160 in collaboration with Tarasov (CRAO, Ukraine), and a paper on this system is forthcoming.

Rosvick (U. College of the Cariboo) used the 1.8-m Plaskett Telescope with the SITE-5 CCD and B, V, and I filters in

August 1999 to observe NGC 6939 and NGC 7209, two intermediate-age open clusters. Further observations of these clusters were obtained during the fourth observing semester (service observations by Balam, U. Victoria). These data will be used to investigate (with VandenBerg, U. Victoria) the phenomenon of convective overshooting in the cores of the stars at the turnoff region of the color-magnitude diagram.

Stetson presented an invited talk on "Uncertainties Affecting the Observational Locations of Stars in Colour-Magnitude Diagrams" at the 35th Liège International Astrophysics Colloquium: "The Galactic Halo from Globular Clusters to Field Stars."

Stetson, with collaborators Hesser and van den Bergh, Bolte and Johnson (U. California Santa Cruz), Harris (McMaster U.), VandenBerg (U. Victoria), Bell (U. Maryland), Bond and Fullton (STScI), and Fahlman and Richer (U. British Columbia), published Hubble Space Telescope WFPC2 photometry for the outer-halo globular clusters Palomar 3, Palomar 4, and Eridanus. They find suggestive evidence that these three clusters may be of order 1.5 ± 1 Gyr younger than the nearby globular clusters M5 and M3, which have comparable metal abundance. This is in contrast to earlier findings for the more massive and more metal-poor outer-halo globular NGC 2419, which was found to have an age indistinguishable from inner-halo clusters of comparable abundance. Whether this is evidence for an age gradient with radius for clusters of moderate metal enrichment, or evidence for a correlation between cluster mass and age (c.f. earlier results for Palomar 12), is unclear. Johnson, Bolte, Stetson, Hesser, and Somerville (Hebrew U.) have similarly published HST color-magnitude diagrams for the old star clusters NGC 1466, NGC 2257, and Hodge 11, in the Large Magellanic Cloud. These clusters are found to have an age indistinguishable from that of the nearby clusters M3 and M92. The blue-straggler populations of these clusters are also found to be normal.

Grundahl, Catelan, Landsman, Stetson, and Andersen have compiled Strömgren photometry for 14 globular clusters. They found a discontinuity in the (V, u-y) morphology of the globular clusters' blue horizontal branches, with stars in the temperature range $11,500 \text{ K} < T_{\text{eff}} < 20,000 \text{ K}$ being systematically brighter than canonical HB models for the same temperatures. They suggest that this effect is due to radiative levitation of heavy elements in this atmospheric temperature range.

Ibata, Richer, Fahlman (U. British Columbia), Bolte (U. California Santa Cruz), Bond (STScI), Pryor (Rutgers), Hesser and Stetson published a paper describing the methods by which they obtained Hubble Space Telescope photometry for the Galactic globular cluster M4 = NGC 6121.

Tian and Jiang (Shanghai Obs.) used the PDS to scan archival plates of open star clusters in collaboration with Stetson and Zhao (Shanghai Obs.).

Stetson prepared an article on "Major Software: Stellar Photometry" for the Encyclopedia of Astronomy and Astrophysics.

Van den Bergh rediscussed the mass of the LMC cluster NGC 1866 and found that a rather steep luminosity function slope of -1.75 ± 0.09 is required to bring the integrated lu-

minosity and velocity dispersion data for this cluster into agreement.

Van den Bergh also considered the relations between globular clusters and dwarf spheroidals. For unknown reasons globular cluster formation appears to have continued in dSph galaxies long after it ceased in the main body of the Galaxy. It was suggested that some of the “young” globulars in the outer Galactic halo might have formed in dwarf spheroidals that were subsequently destroyed.

3.6 Binary Stars

Bohlender, in collaboration with Paunzen (Vienna), continues to obtain spectra of several potential spectroscopic binaries among the peculiar λ Boo stars with the 1.2-m telescope. These data have the potential to provide relatively accurate mass and evolutionary states for these stars.

R. E. M. Griffin (Oxford U.) used the 1.2-m coude spectrograph for a three-week run in the third quarter of 1999 to monitor the K-line region of the eclipsing ζ Aur system 22 Vul. The coverage included 6–7 nights each of ingress, totality, and egress. The data have been reduced, and analysis is underway. Observations were also made of the composite binary system α Equ, which fortuitously passed through a phase of maximum velocity separation between the components during the observing run. To complete the observations needed for a thorough analysis of α Equ, another observing run was successfully executed in October, when a maximum velocity separation was presented in the opposite sense. She also used the PDS machine to digitize ten of the high-dispersion DAO spectrograms of α Equ previously analyzed by Rosvick and Scarfe.

The digital scans she made last year of early-type stellar spectrograms, primarily from the DAO plate archive, have now been extensively analyzed as part of a collaboration with David and Verschuere (Antwerp). The aim is to determine the precision with which the radial velocities of stars of spectral types late B to early F might be measured. A full analysis of the results has been written for submission to *Astronomy and Astrophysics*. The spectroscopic survey of a transient emission line of Si I in certain composite-spectrum binaries, largely carried out at DAO during 1999, is now being written up in collaboration with Harper and Bennett (U. Colorado), who are responsible for the theoretical explanation of the phenomenon.

R. F. Griffin (Cambridge Obs., England) made four visits to use the radial-velocity spectrometer (RVS) at the 1.2-m telescope. The objects of principal interest to him were the many spectroscopic binaries on which he has been keeping a watch, in some cases for decades; he was also able to make progress with a survey program that includes many stars in the vicinity of the north celestial pole.

Scarfe (U. Victoria) has continued to obtain radial velocity observations of binary and multiple stars with the 1.2-m telescope, chiefly with the RVS, although photographic observations are still obtained for a small number of objects for which more accurate data over a long period are required. Among the latter is the system of 64 Ori, which includes three late B-type stars, two of whose spectra are measurable. In collaboration with Fekel (Tennessee State U.) and Barlow

(U. Victoria), a new three-dimensional orbital solution of that system has been obtained. Despite the inaccessibility of the third spectrum, masses and luminosities for all three components have been determined, assuming that they lie on the mass-luminosity relationship for the main sequence. A description of those results has been accepted for publication in the *Astronomical Journal*.

3.7 Stellar Spectra & Radial Velocities

Adelman (The Citadel) is preparing an atlas of the spectrograms of Deneb that Berahitdin Albayrak used for his Ph.D. thesis.

Bohlender is continuing his spectroscopic studies of long period (>6 days) Ap stars, specifically the helium line profiles of the so-called “sn” stars, and the helium abundance geometries of the helium-peculiar stars.

Bohlender and Sigut (U. Western Ontario) are using the 1.2-m telescope and coude spectrograph to conduct a search for emission lines in the spectra of helium-weak and HgMn stars at wavelengths longer than 6000Å. Sigut serendipitously discovered weak Mn II emission lines in 3 Cen A and 46 Aql with CFHT’s Gecko spectrograph. They are using DAO facilities to search for other stars showing emission features and for additional emission features at other wavelengths. They have found at least one other early-type star with emission features.

Bohlender is continuing a few long-term programs of H α spectroscopy on the 1.8-m telescope. These include a search for optical evidence of magnetospheres in the helium-peculiar stars, and a search for emission variability in the Ae-shell stars. He was awarded 3.5 nights of CFHT and FTS time to obtain high-S/N, high-resolution spectra of the He I 10830 Å line in late-A and early-F dwarfs in order to search for the convective envelope boundary in main sequence stars. Many data were obtained in 1999 September and four additional nights have been allocated to extend this survey to the early-A type stars.

Gulliver (Brandon) and Adelman are completing a paper on the radial velocities of the stars of the Ursa Major stream. They find that the coude instrumental system is more stable than the standards for early-type stars.

Kerton (HIA) and Balam (U. Victoria) obtained classification spectra of the star BD+60° 2607 using the 1.8-m telescope. This star was thought to be the exciting star for the small H II region S 166 based on its projected position at the center of the region; however, the new spectra show that the star is actually a foreground early F-type star.

Larson (Western Washington U.) and undergraduate student Zylstra are using the Plaskett Telescope to search for H α emission from T Tauri candidates at high Galactic latitude. These candidates were identified as infrared excess objects from analysis of new 2 μ m data from the All-Sky Survey (2MASS).

Rice (Brandon) and Bohlender began to obtain phase-resolved spectra of the bright magnetic Ap star θ Aur in order to model the oxygen abundance geometry of the star.

Wallerstein (U. Washington) used the 1.2-m coude spectrograph with the UBC 4096 CCD on several programs. A number of S-type stars, which are defined by the presence of

ZrO bands, were observed in the 7700–8100 Å region and the 8500–8800 Å region to determine the ratio of Ti/Zr from their neutral lines. The data are being analyzed by Vanture (Everett Community College). For a program in cooperation with Laws (U. Washington), spectra of a number of dM stars were obtained. Because of the faintness of most dM stars, that program is continuing into 2000. In October, in cooperation with Gonzalez (U. Washington) and Latham (Harvard U.), Wallerstein obtained spectra with a resolution of 35,000 of the Li line region in stars suspected of having planetary companions. Additional radial velocities are being obtained by Latham to confirm binarity and derive orbital elements. Exploratory spectra of resolution 70,000 were recorded by using the second-order red on a number of red giants for the Ca I line at 6572 Å. The line profile will be used to establish the boundary temperature of the target stars, whose effective temperature is well known.

3.8 Interstellar Medium

Walker (U. British Columbia), Krelowski (Nicolaus Copernicus U.), and Bohlender used the high-resolution Gecko spectrograph at CFHT to obtain extremely high signal-to-noise (~ 1000) spectra of several reddened hot stars to investigate the profile shapes of various diffuse interstellar bands. Resolved, triple structure seen in some of the more narrow features has been interpreted as evidence for carbon isotope variations in large, symmetrical carbon molecules. Additional data are also being analyzed. The group is closely interacting with Maier's (Basel) laboratory group in order to compare new gas-phase spectra of carbon chain molecules with the Gecko spectra.

3.9 Asteroids & Comets

With two contributions to the Minor Planet Electronic Circulars, Aikman (Seameadow Astronomics Inc.) continued his astrometric measurements of near-Earth asteroids with the Plaskett Telescope.

Balam (U. Victoria), along with students Clem, Greimel, Taylor, Cardinal (U. Victoria), and Parker (Mount Allison U.), continued to use the Plaskett Telescope for immediate confirmation and follow-up astrometry of newly discovered near-Earth objects (NEOs). The Plaskett Telescope is the largest telescope in the world that is used in a regular program of NEO follow-up astrometry, so that the telescope is able to detect these objects long after they have faded from the grasp of other observers. Without this work, many of the near-Earth objects would be permanently lost. In particular, observations were acquired and the arc lengthened of all of the 'near-miss' asteroids that have been the subject of controversy during the year.

The program was awarded 102 nights during 1999, with additional observations made by U. Victoria and visiting summer students during their scheduled nights on the Plaskett Telescope. In all cases the astrometric data were submitted to the Minor Planet Center at the end of each night, resulting in the issuance of 38 Minor Planet Electronic Circulars and two IAU Circulars. One hundred and ninety-five asteroids were tracked during 1999: 5 members of the Aten

class, 61 Apollo (Earth-crossing) asteroids, 63 Amors (Mars-crossing and Earth-approaching) and 58 main-belt (mainly Flora family members, Hungarias and high-inclination objects) asteroids. Thirty-five objects are classified as 'potentially-hazardous asteroids.'

4. DAO TELESCOPES

The 1.2-m McKellar Telescope was used for astronomical observations for 1630 hours on 218 nights during the reporting period. This compares with an average of 1387 hours on 211 nights over the last 16 years, or with 1427 hours and 216 nights for the period 1991–2000. The subscription factor was 82% averaged over the fiscal year. CCD detectors were employed on 73% of the useable nights, the radial velocity scanner on 26%, and photographic plates on 1%. Of the 320 scheduled nights, 53% (171 nights) were used for projects led by Canadian astronomers not at NRC, 1% (45 nights) by NRC astronomers, 13% (41 nights) by U.S. astronomers, and 20% (63 nights) by other foreign astronomers. Seventeen scientists, including one student, were involved with twelve distinct programs.

The 1.8-m Plaskett Telescope was used for astronomical observation for 1464 hours on 205 nights. This compares with an average of 1179 hours on 192 nights for the past 16 years, or 1275 hours on 194 nights for the period 1991–2000 (since the last major engineering upgrade of the Plaskett Telescope). The subscription factor was 136% averaged over the fiscal year. IR imaging was employed on 8% of the useable nights, CCD imaging on 62%, and spectroscopy on 30%. Of the 353 scheduled nights, 81% (292 nights) were assigned to Canadian investigators not at NRC, 10% (37 nights) to NRC astronomers, 4% (14 nights) to U.S. astronomers, and 5% (18) by other foreign astronomers. Thirty-seven scientists, including eight students (with data potentially contributing to five theses), were involved in 34 distinct research programs.

Thus, despite what seemed to be a particularly cloudy winter, more hours were used on both telescopes than in any year since 1992–1993; in fact, it was the second best year since 1969–1970.

Businesses owned and operated by Chris Aikman, David Balam, and Frank Younger offered service observing to DAO telescope users. This service, first offered in late FY97/98, continues to be popular, as users do not have to miss classes and are charged by the contractors only for hours worked. In FY99/00 57 nights (18% of scheduled nights) on the McKellar Telescope were for contract service observing, while 39 nights (11%) on the Plaskett Telescope were so scheduled.

5. CANADIAN ASTRONOMY DATA CENTRE (CADC)

CADC now has a total of 1170 registered users in 59 countries around the world and an unknown number of casual users of their many services that do not require registration. Archive activity grew dramatically during 1999 regardless of how activity is measured.

5.1 HST Archive

The HST Archive continues to be funded by the Canadian Space Agency, which facilitates the purchase of data, the development of innovative archive access tools, and travel to archive coordination meetings.

The WFPC2 association project, a CADC/ST-ECF collaboration, is nearing fruition with the implementation by Schade of a cross-correlation procedure that makes it possible to stack all associated images with sufficient signal into a cleaned and combined image. In the past only frames with good jitter information could be processed in this way. This improvement will make possible the creation and distribution of superior data products including previews. Furthermore, the WFPC2 archive will be accessible to data mining techniques.

At the present time, about 50% of the estimated WFPC2 16,000 stacks (images created by averaging processes from sets ranging in size from 1 to 60 raw images) have been cross-correlated successfully. The computing effort required eight months to complete. The next phase of the process is beginning with the production of WFPC2 source catalogues with positions, and photometry.

Gaudet and Jaeger migrated all remaining HST data from optical disks to CD-ROMs so that all HST archive operations are now independent of the older, near-obsolete media. Migration of HST data to DVD is in progress in collaboration with ST-ECF. Durand and Gaudet, with colleagues from ST-ECF, maintained the HST recalibration system, as well as the preview system. Close coordination was maintained between CADC, ECF, and STScI archiving staff.

During 1999 CADC dealt with 38,152 queries of the HST catalogue returning details on 497,832 entries. Both of these numbers represent increases of more than 100 and 127,800 datasets with a volume of 180 Gbytes of data were delivered.

5.2 CFHT Archive

During the first decade of CFHT archive operations a total of 300 Gbytes of (compressed) data were produced by the telescope (excluding the UH8K camera which was commissioned near the end of this period). During the 15-month period 1999 January to 2000 April a total of 3000 Gbytes of data were delivered on 92 DLT tapes. So, 90% of the data volume of CFHT since 1989 has been produced in the past 15 months and the MegaPrime era has not yet begun.

Durand finished the work with guest worker G. Raviv on automatic classification of CFHT images within the archive. This includes the implementation of a pipeline that establishes the world coordinate system for each of these images (pixel to sky). This work has been implemented within the CADC CFH12k pipeline.

Gaudet and Jaeger initiated the migration of CFHT data from Sony optical disks, Exabyte tapes and DLT tapes to CD-ROMs and DVDs. Eighty-six percent of the files have been transferred, but, due to the large size of mosaic camera images, the files transferred represent only 10% of the data volume. Gaudet worked with CFHT to set up the automatic transfer of files using routines from the Gemini software. Bohlender ingested the CFH12k header information into CF-

HT's science catalogue and developed a new web interface for the CFHT archive.

CADC continues a co-operative arrangement with the TERAPIX group in France whereby information on data processing and analysis for mosaic cameras is being shared. A higher level of collaboration is expected now that CFH12k data are flowing, making it possible to develop prototype pipeline systems. CADC is designated as the archive site for processed TERAPIX data and is beginning, with CFH12k, to address the archiving issues that arise from such data.

Scientific collaborations involving Schade have led to access to mosaic camera data from CFH12k, the NOAO mosaic camera, and the ESO Wide-Field Imager. CADC now has datasets from all of these cameras in the processing phase and thus is learning about the similarities and differences of the systems and their various data-processing requirements.

During 1999 CADC handled 24,775 queries of the CFHT science catalogue returning details on 438,662 datasets. Both of these numbers represent increases of more than 100% over last year. A total of 139 data requests were processed and 54,080 datasets with a volume of 61.3 Gbytes of (compressed) data were delivered.

5.3 James Clerk Maxwell Telescope (JCMT) Archive

Bohlender and Gaudet helped to complete the biannual JCMT catalogue and data update. The SCUBA preview and recalibration pipeline is being installed at CADC with the help of JCMT staff from Hilo. When completed, it will be possible to offer "recalibrated" SCUBA data to CADC users.

The JCMT archive processed 2107 catalogue queries in 1999 and returned information on 88,516 individual datasets. A total of 177 requests were made for 3441 datasets. The requested data volume was 338 Mbytes. The arrival of SCUBA data will result in a significant increase in JCMT volume.

5.4 Canadian Galactic Plane Survey (CGPS) Archive

With delivery of the first four CD-ROMs, data from the Canadian Galactic Plane Survey have started their migration into CADC's archive; the effort is supported by Durand and Higgs (HIA). At this early stage, 7 requests for 41 datasets totaling 1.15 Gbytes of data have already been processed.

5.5 International Ultraviolet Explorer (IUE) Archive

CADC will be acting as the North American Principal Centre for the Final Archive for the International Ultraviolet Explorer satellite. Bohlender installed the IUE Final Archive system on one of CADC's PCs. Release to the community should be taking place in early April 2000. Almost all of the IUE/INES data are available.

5.6 Gemini Activities

Gaudet worked with Woodsworth, Durand, Hesser, and Schade throughout the year to secure the Gemini Science Archive Conceptual Design contract jointly with Chile. Gau-

det visited Chile to participate in the hiring of a Chilean software engineer and in discussions with CONICYT and potential university partners. These efforts follow earlier presentations by Schade at both CONICYT and U. Chile. As a result, the partners signed a contract in January 2000 and design work began in February 2000. F. Richardson M., a software engineer employed by CONICYT, began work in Victoria at the end of February. The goal of the contract is to deliver by the end of 2000 a conceptual design and costing estimates for implementing and operating an archive based on that design. Gaudet is the project manager and Hill is the lead software engineer, assisted by Richardson. The first significant deliverable, the draft initial Operational Concept Design Document, was ready on March 7, ahead of schedule.

In July, Hill and Gaudet delivered to Gemini an updated version of the Data Handling System (DHS) that also supports internal CADC operations relevant to archival implementation.

During the same trip to Hawaii, Hill and Gaudet presented an overview of a detailed design for an optional Gemini data processing system component of the DHS delivered by CADC to Gemini in 1998.

Gaudet secured a contract with Gemini to provide software support for the DHS. Work will be performed on an as-needed basis, primarily by Hill, Jaeger, Gaudet, and Dunn.

5.7 Data Mining

Hill and Gaudet designed, and began implementing a data processing infrastructure for CADC.

Schade and Durand developed plans and proposals for data mining initiatives at CADC, which were partially supported by NRC's Vice-President, Technology and Industry Support in order to start data mining experiments with the CFHT12K camera data as a step towards TERAPIX. As a consequence, CADC was able to hire Dowler and Zingle to work on software.

Dowler, Gaudet, Schade, and Durand designed and implemented a prototype architecture for a Data Mining Server (DMS) architecture in JAVA. Substantial progress has been made in the past year in defining the problem and developing tools and methods to implement this system. The result is geared toward the design of a broader, more general science database and virtual observatory. The group initiated testing of suitable tools and technologies. In parallel, Durand and Schade, with help from ST-ECF, implemented the first phase of the WFPC2 data-mining pipeline. The time required for this effort was much greater than previously estimated, but much was learned during this process which could help for the next phase.

One important aspect of data mining is developing the right tools to handle the billions of measurements from the extracted information. Dowler and Hill are taking the lead within CADC to experiment and to identify the appropriate procedures.

Zingle experimented with user-interface technologies to provide more powerful access to the existing CADC facilities and to the data mining system.

Dowler and Durand implemented a prototype of a new CADC preview system that delivers compressed astronomical images directly to the user via a web interface and enables rapid and powerful evaluation of the available archive data.

5.8 Usage of the Digital Sky Survey (DSS)

During 1999 CADC approached a milestone of sorts in the delivery of services as it delivered 330,000 images from the DSS to CADC users or nearly 1000 images each day. Durand plans to migrate the DSS to magnetic storage, which will result in much faster access and delivery time as well as much-reduced wear and tear on the CD-ROM jukeboxes that currently store and serve the images.

5.9 Miscellaneous Activities

The computing environment at CADC began to change during 1999. Durand developed a plan for CADC migration from X-terminal architecture to PCs using the Linux operating system, which was implemented for all CADC personnel by Dowler in 2000 January. Each of these machines is equipped with two processors and 50 Gbytes of disk space. Together, they allow CADC to operate a small in-house BEOWULF system. Dowler also developed an automatic Linux update procedure of general utility as Linux becomes more widely used at the Observatory.

Durand continued to support the XDSS duplication effort led by the Catalogue and Data team at STScI. Similarly, he continues to support IRAF/STSDAS releases for HIA Victoria. He also maintains the basic infrastructure needed for CADC participation in the international effort on standardization of data archive services. For example, Astrobrowse is a utility that enables the astronomical community to query many astronomical databases at once for target data. GLU is a client/server system, which sends changes made at one site to all other registered sites, ensuring that everyone on the network has the same copy of resource descriptions.

CADC acquired a 700-slot DVD jukebox, which drives the online optical storage capability over the 4-terabyte mark. Jaeger produced the first DVD for CADC. Although this is a step in the right direction, it does not provide sufficient space for data from the CFH12k and larger mosaic cameras.

Gaudet implemented a PVM distributed framework for Schade's *galfit* software to run on the DRAO/CADC Beowulf system. Schade used the Beowulf system intensively during February completing what would have been a six-month job in a period of three days.

Bohlender and Durand continued the development and support of the Phase One Observing Proposal System (POOPSY) for CFHT. Most of the changes required to support DAO's telescopes with the same tool have been implemented. Bohlender began to investigate the code changes and enhancements needed to support Gemini XML requirements, but curtailed this activity when the Canadian Gemini Science Committee (CGSC) announced support of Gemini's Phase One Tool for Canadian Gemini proposals.

In May, Gaudet, Jaeger, and Hill completed the ASTO contract with the delivery of a functioning archive media creation system to ESO. The ASTO software will be used by ESO's VLT archiving system.

Gaudet and Véran supervised the porting of compFITS to use CFITSIO and to support multi-extension FITS files. Extensive testing was performed. In addition, Dowler built the HCOMPRESS class component for CADC. The class, which is very useful when using data transmission over the WEB, was released publicly under the JSky consortium.

Gaudet and Schade promoted CADC collaboration in U. Victoria's High Performance Computing and Mass Storage initiatives. Gaudet attended several meetings to represent HIA and CADC issues and formal offers of support were made.

ADASS 2001 will be hosted in Victoria by CADC/NRC. Durand and Gaudet established arrangements with U. Victoria's Conference Services Office to manage the meeting, which will be held at the Victoria Conference Centre.

Van den Bergh discussed the importance of large homogeneous data samples to the astronomy of the Twenty-first Century.

6. COMPUTER SYSTEMS & LIBRARY

6.1 Computer Systems

During the fiscal year, approximately 40 PC workstations were either deployed or reconfigured and redeployed, bringing the total number of desktop systems supported in Victoria to approximately 140.

A Microsoft Exchange server was installed and commissioned as part of the new NRC-wide messaging system. At fiscal year end, 80 Exchange e-mail users in Victoria and three in Penticton are using this server.

An Ultra 250 was installed and customized as the new Sybase server for CADC and the installation of a new Ultra 450 for general Unix services was completed. Other hardware upgrades included new CPUs, memory, and more than a terabyte of new disk space in the CADC and science computer servers, in anticipation of large new data sets from the CFH12K camera and radio interferometers.

New LAN switching hardware provided by NRC's Information Management Services Branch was installed in both Victoria and Penticton. A new set of IP addresses was partially implemented because Victoria had exhausted the available address space. As well, the introduction of multiple private address ranges using the routing capability of the new switch began, both for security reasons and to address the exhaustion of address space.

Preparation for the Y2K event, including the upgrade of some Sun Unix servers to Solaris 2.6, and the application of a patch kit to those Sun systems remaining temporarily at Solaris 2.5.1, allowed all Unix systems to enter the year 2000 with essentially no disruptions. The PC systems survived the Y2K transition with only two minor problems, both easily fixed.

After a security breach during the summer, several months were spent tightening security across all Unix servers.

A weekly luncheon users' forum initiated this fiscal year improved communications between users and computer Group staff.

6.2 Library

The librarians LeBlanc and Hanna and advisor Hutchings completed the second year of planned budget cuts totaling 60%. The library has had to consolidate its acquisitions to essential astronomy serials, with little extra for monographs or other subjects. Many journals are now available electronically, and copies from the remainder are obtainable via NRC's main Canada Institute for Scientific and Technical Information library. Career Edge student Faro Sullivan finished her one-year term on April 16, completed her two main projects: bar-coding DAO's library collection, and scanning the 1913–1960 newspapers clips dealing with the observatory and local astronomy activities. LeBlanc has also been a member of the HIA Visitor Centre Committee, mostly reviewing the exhibit texts as prepared by AldrichPears Associates.

7. INSTRUMENTATION & SOFTWARE

7.1 CFHT Instrumentation

Following the 1999 April refresher meeting of CFHT, HIA, and CEA (France), HIA's commitment to Mega Prime, the one-degree field-of-view CCD imager, was formally defined. HIA is responsible for the delivery of the Focus Stage Assembly (FSA), the Guide and Focus Sensor Units (GFSU), the software that handles the GFSU CCD readout and guide star centroid calculation, and the overall MegaPrime Assembly drawings. Fitzsimmons, as Project Manager, coordinated the HIA MegaPrime effort, which saw detailed design work completed by Fitzsimmons, Hardy, Leckie, Morbey, and Roberts. The purchasing of manufactured and stock components will begin in FY2000/2001, leading to the assembly, testing, and delivery of the MegaPrime instrument components to CFHT within the next fiscal year.

7.2 Gemini Multi-Object Spectrograph (GMOS)

Crampton continued as co-project scientist (with R. Davies, Durham) for GMOS. To fulfil this role, Crampton spent 1999 October to 2000 April in Edinburgh. Similarly, Murowinski, as Project Manager for GMOS North spent a large fraction of the year in Edinburgh to participate in the instrument integration.

The first GMOS, destined for the Mauna Kea telescope, reached a number of major milestones in the past year. The instrument optical barrels, assembled and tested by Fletcher and Stilburn, were found to deliver exquisite throughput and an image quality that fully met the very demanding specification. The barrels were delivered to the Astronomy Technology Centre at ROE in 1999 October. The second major contribution to the instrument, the prefocal assembly, was completed in 2000 February and represents the unified effort of most of the Optical Instrumentation Group. This assembly has also been shipped to ROE for integration with the rest of

the instrument. Integration is expected to reach completion for delivery to the telescope by 2000 December. Descriptions of progress and results of tests can be found in the proceedings of the 2000 March Munich SPIE meeting.

The second GMOS, destined for the Cerro Pachn telescope, received most of its parts in the past year. During mid fiscal year Szeto assumed responsibility as Project Manager for this instrument. Since integration and testing of the first GMOS had a higher priority, there was no plan to start any major integration of the second GMOS in 1999/2000. However, the second GMOS optical barrels and prefocal assembly are expected to be shipped to ROE in the last quarter of 2000.

7.3 Gemini Adaptive Optics System (Altair)

Herriot and Morris continued as Gemini Adaptive Optics (Altair) Project Manager and Scientist, respectively. Altair passed its Critical Design Review in 1999 February and is now well into its manufacturing phase. Production of detailed manufacturing drawings began, under the direction of Roberts. Key components such as deformable and tip/tilt mirrors were ordered. Actual construction of Altair commenced with successful welding of frames for the electronics and for Altair's overall enclosure, while fabrication of the optical bench and of the electronics also began. Major effort on software, led by Saddlemeyer, resulted in a first test of motion control for guide star acquisition and also control system timing tests. Altair delivery is expected in 2001 September.

Véran reviewed his work on adaptive optics as an invited speaker at the "Forum de la Haute Résolution Angulaire" held in Grenoble, France in 1999 June, as well at U. Laval and U. Montréal, and was an invited speaker at the 1999 Astronomical Data Analysis Software and System conference.

7.4 Gemini Wavefront Sensors (WFSs)

Leckie and Hardy completed the assembly and testing of the remaining WFSs (two CCD47s were completed in August and three CCD39s were completed in January). Two new initiatives to enhance the reliability of the WFS systems were started. At the request of the Gemini Project Office, Hardy undertook hardware and software changes on the VME interface cards. He also made improvements to the timing board boot code (wait state elimination), repaired software bugs (simulated data format), and provided higher reliability, low-power, programmable array logic ICs. Leckie undertook the coordination of investigations into solutions for glycol leaks in the cooling systems for the WFS housings. He proposed changes to the WFS heads so that the temperature of the heat sink could be measured.

7.5 Gemini Data Handling System (DHS)

Under Gaudet's project management, and with the participation of all CADC computer scientists, the DHS software was delivered in 1999 June to IGPO. In 2000 February, CADC and IGPO established a maintenance contract. The

DHS is now partially integrated with CADC operations, with the storage server being used to creating CD-ROMs for users and the archive.

7.6 Other Gemini

HIA has been working closely with the IGPO to prepare for a Conceptual Design Review for the Multi-Conjugate Adaptive Optics System for Gemini South. This system is being designed to produce diffraction-limited images across a 1–2 arcminute field of view. HIA staff involved include Roberts (mechanical design), Saddlemeyer (software and computing hardware), Véran (reconstruction and PSF estimation), Herriot (systems engineering) and Morris (science case).

Durand (CADC) worked with Véran to investigate sky coverage of guide stars. The study is continuing with the pre-release version of the GSCII. A review paper was jointly presented at ADASS 1999.

7.7 Far Ultraviolet Spectroscopic Explorer (FUSE)

Murowinski and Hardy took part in final integration and testing of the FUSE hardware built by ComDev (Cambridge, ON) prior to shipping for launch. After launch, they were involved in several investigations of operational problems and this continues. The FES engineering model is in the Electronics Laboratory in Victoria for this work. The FES and software work well and are in constant use in science operations. The hardware has also been featured during several VIP visits and press events on the FUSE mission. Hutchings has worked on the initial observations and science with FUSE.

7.8 Next-Generation Space Telescope (NGST)

The Observatory hosted a NASA, ESA, CSA NGST meeting in April. Several instrument concepts were investigated as potential Canadian contributions to NGST. Lilly (U. Toronto) is Canadian Project Scientist for NGST activities. Crampton and Roberts led studies of the Near-Infrared Multi-Object Spectrograph (NIR MOS) concepts, in cooperation with colleagues and students at U. Victoria, Simon Fraser U., Camosun College, EMS Technologies (Ottawa), and EHR Optical Systems (Victoria). In an effort led by Hickson (U. British Columbia) and EMS Technologies, Hardy, Hutchings, Morbey, and Murowinski contributed to concept studies for a high-resolution imager. Morris led a study of an imaging Fourier transform spectrometer in collaboration with BOMEM (Quebec). In collaboration with Graham (U. California, Berkeley), a prototype interferometer is now ready for testing on the ARC telescope. All told, 17 students of astronomy and engineering contributed to the intense NGST efforts. The results of all of these studies were presented at the NGST Science and Technology Exposition in Hyannis, MA in September 1999. Hutchings and Murowinski served on the NGST Ad-hoc Science Working Group and the NGST Technology Review Panel, respectively.

7.9 Canadian Ultraviolet Imaging Telescope (CUVIT)

Hutchings (as Principal Investigator) and Murowinski supervised a contract with Routes Inc. to develop breadboard electronics and software for shift-and-add image accumulation in real time to compensate for spacecraft drift. Hutchings has maintained contacts with other UV imaging telescope projects, to seek possible partnerships for the projects.

7.10 Very Large Optical Telescope (VLOT)

Canadian astronomers explored various ideas for increasing their access to large optical telescopes. One, coordinated by Carlberg (U. Toronto), led to a proposal for a wide field 8-m telescope submitted to the Long-Range Planning Panel. Another option examined is that of a 15-m telescope that would have excellent angular resolution in a narrow field of view and be capable of wider field studies. Morbey produced preliminary optical designs for these options. Studies for multi-conjugate adaptive optics technologies are being pursued at HIA for Gemini as well as VLOT. Based on these and other experiences, HIA is contributing to the Canadian proposal in response to CFHT's call for conceptual studies for a replacement facility to be presented at their 20th anniversary celebration in 2000 December.

The other effort has been exploring international collaborations that could lead to a 30- to 100-m-class telescope. As part of this, Hesser, Morris, and Roberts, with Halliday (AGRA Coast), participated in the AURA MAXAT workshop in September. Morris is helping a group at NOAO Tucson prepare their proposal to the U.S. NSF, with the goal of coordinating effort and obtaining full intellectual involvement for Canada in any resulting collaboration, while Hesser is involved in coordination discussions between NOAO, Australia, and Canada.

7.11 Other Instrumentation

The two-layer antireflection coating developed by Stilburn at HIA was applied to the 12 glass surfaces of the GMOS optics. An application for a patent on this coating submitted to the U.S. Patent Office was accepted. Later in the year, a further improvement to the durability of the coating was made by treatment with a Teflon-like polymer.

In summer 1999, the California-based Center for Adaptive Optics (CfAO) won US\$19 million in funding from the NSF. Véran was invited to participate in the preparation of the successful proposal and HIA/NRC is now one of the three non-U.S. institute partners of the Center. Collaborative work will soon begin in the area of the post-processing of adaptive optics data, including deconvolution, photometry, and PSF reconstruction. This work will be directly applicable to Altair. Interaction with the CfAO will include participation in meetings and CfAO graduate and postgraduate students visiting HIA.

Instrumentation Group activities were a focal point of the first meeting ever held at HIA of the Industrial Technology Advisors of NRC's Industrial Research Assistance Program (IRAP), which was organized by M. Ward. Several technical consultations were provided to local entrepreneurs by Group members as a result of IRAP referrals by Ward. There were

also numerous interactions with consultant Hashim Mitha aimed at exploring technology transfer opportunities of HIA instrumentation development activities.

NGST and Gemini engineering projects involving Camosun College mechanical engineering students were featured at a Camosun Open House in March.

Herriot and Véran, with Yeung (JCMT), participated in the B.C. Advanced Systems Institutes Exchange in Vancouver, where Herriot judged the graduate student displays and Yeung and Véran hosted the HIA display booth.

8. OUTREACH PROGRAM

Group tours throughout FY99/00 were conducted under contract by Aikman through his Seameadow Astronomics company; during July and August, and on other occasions, he was assisted by U. Victoria student Bolduc-Duval. Of the 119 group tours, 11% were for kindergarten and pre-school groups, 50% for elementary, 35% for secondary, 3% for post-secondary, and 6% for adult groups. In total, 2747 people participated in group tours, the minimum size of which is set at 15.

Aikman, assisted in July and August by Bolduc-Duval, ran the 30 Saturday night open houses at the Plaskett 1.8-m telescope from April through October; Saddlemeyer and Bond provided technical support on Saturday evenings. More than 1700 members of the public visited on those occasions. Younger and Balam (U. Victoria) volunteered their support on many evenings, as did a core group of volunteers from the Victoria Centre of the Royal Astronomical Society of Canada: Sandy Barta, Chuck Filtness, Richard Harvey, David Lee, David Luttmann, Ed Maxfield, Rick McCrea, Ed Nicholas, Frank Ogonoski, Eric Schandall, Peter Schlatter, Jeffery Sutherland, and Guy Walton. The RASC volunteers brought their telescopes to DAO and shared their knowledge and enthusiasm with members of the public to excellent effect. Their efforts were well supported by Commissionaires D. Stobbart and J. McNair, with occasional assistance from B. Alcool and U. Arthur. The grounds and display gallery remained open to the public during office hours and summer weekends, and attracted large numbers of additional visitors.

With Kennedy (NRC Ottawa), Hesser and Côté, in collaboration with graphic designers at Teach magazine, developed a bilingual poster that was distributed to more than 30,000 teachers in Canada via Teach and its Quebec counterpart, Rescol. The poster has eight pages of text and a star map with information and activities that are closely tied to national criteria for K-12 science education.

As part of the Cosmic Flows workshop (§3.1), Prof. R. Kirshner (Harvard U.) gave a public lecture that drew a large audience at U. Victoria.

During the tripartite NGST meeting (§7.8), Canadian project scientist S. Lilly (U. Toronto) presented a well attended public lecture at U. Victoria on NGST.

In collaboration with Gower (U. Victoria), Hesser arranged and hosted a public lecture by Canadian astronaut Julie Payette, who spoke to a capacity audience in March.

Special open houses were coordinated at DAO on the occasion of the Cosmic Flows workshop in July, as well as for the meetings of the Antique Telescope Society in September.

In 1999 November, DAO staff hosted 21 students from 13 area secondary schools for a “career shadow day” coordinated by Briana Robertson.

Construction began during the fiscal year on a Visitors Centre that is located between the dome of the Plaskett Telescope and the White House on Little Saanich Mountain. The new Centre will have a display area featuring work of Canadian astronomers, a small Star Lab planetarium, a 60-seat theatre, and a display area for NRC activities, as well as supporting infrastructure. The 0.4-m telescope is being relocated and attached to the main display hall, on a stable platform on the south-west wall of the facility; RASC members will be able to set up their telescopes on the platform, as well. Oke chaired the HIA Visitor Centre Committee, whose members are Currie, Hesser, Hutchings, LeBlanc, and Vallée. Marilyn Smith (NRC Creative Services, Ottawa) spent extended stays in Victoria working with HIA and AldrichPears Associates, the contractors who are designing the content of the Centre, and with the architects. Oke also presented the project on local television.

Bond and Barton supported filming of the Observatory for a local TV production crew that pictured the Plaskett dome in a publicity campaign.

9. MISCELLANY

Barton gave invited lectures on tidally triggered evolution in close pairs of galaxies at U. British Columbia and at U. Washington.

Batten’s proposal for the forthcoming IAU General Assembly in Manchester was successful, as a result of which there will be a 2.5-day Special Session on “Astronomy for Developing Countries.” Batten gave two invited presentations to the 1999 Antique Telescope Society conference in Victoria, one on the Dorpat Observatory and Wilhelm Struve, and one on the history of DAO.

Bohlender, Durand, and Gaudet arranged a JCMT archive coordination meeting at the Joint Astronomy Centre in 1999 September. Bohlender chaired the Canadian Time Assignment Committee for CFHT, and was appointed to the CFHT Scientific Advisory Committee.

Courteau chaired the scientific and local organizing committees of the Cosmic Flows workshop held at U. Victoria, 1999 July 13–17; Hesser and Morris served on the LOC.

Courteau continued his educational and outreach activities. He was active visiting elementary and high schools in the greater Victoria area as a member of the B.C. program “Scientists and Innovators in the Schools,” and continued his monthly astronomy presentations on the CBC/SRC radio morning show “CBUF-Bonjour.” He also presented an invited talk at the American Physical Society’s NW meeting in May.

Crampton received an NRC–British Council Collaborative Research Award to explore science and technical collaborations with colleagues in the U.K. during his extended visit to Edinburgh. As an adjunct professor, he supervised U. Victoria graduate students Gwyn, Swerdlyk, and Steinbring. Crampton chaired a review of the Keck Telescope instrument, ESI.

Crampton, Gaudet, Hare, Herriot, Hesser, and Murowinski participated in the “Gemini Lessons Learned” workshop organized by Woodsworth. Hare, with assistance from Hesser, prepared the proceedings.

Durand spent two weeks at NOAO working on catalogue connectivity tasks with the IRAF group; this short stay triggered new activities for CADC catalogue access within IRAF. He gave workshops on how to use CADC to faculty and students at U. Montréal and U. Laval in 1999 June, as well as at CASCA 1999. With Gaudet, Durand participated in the HST co-ordination meeting held at STScI in 2000 February. As well, Durand participated in the second National Virtual Observatory meeting held in Tucson, AZ in 2000 February.

Gaudet participated in the Gemini Lessons Learned workshop held in 1999 July at Parksville, B.C. He presented a full day seminar on the DHS design to the Gemini Software Group in Hilo, HI in 1999 June. He also served on HIA’s Employee Advisory Committee for the NRC Performance Bonus Program, and on the NRC Software Development Guidelines Working Group.

Herriot represented HIA at a Victoria meeting of British Columbia’s Advanced Systems Institute (ASI) Exchange, a group that promotes synergistic relations among universities, industry, and government laboratories.

Hesser was honored by the Bernardo Houssay Distinguished Lectureship by U. Buenos Aires, where he presented a popular-level lecture on results from the HST, as well as technical lectures on ages of the oldest stars in the Milky Way and satellites. He also spoke on the organization of Canadian astronomy with an emphasis on how Canada has organized to support Gemini. The latter two subjects were also presented at U. Cordova and U. La Plata. He was further honored by the U. Kansas, 1999–2000 College of Liberal Arts and Sciences Alumni Distinguished Service Award.

Hesser served as Vice-Chair of CFHT’s Board of Directors, and was elected Board Chair for 2000–2001. He continued on the Board of Directors of the Associated Universities for Research in Astronomy, where he served on the Long-range Planning Committee for NOAO. Hesser chaired one of the three review panels for the first-ever joint NASA-NSF Announcement of Opportunity for Space Interferometry Mission preparatory science and Nearby Stars research. He served on the CASCA Nominating Committee. He reviewed optical instrumentation projects and lessons learned from them at a Quebec workshop hosted by U. Montréal, and served as the HIA liaison with the organizers of the Antique Telescope Society meeting. He continues as an adjunct professor at U. Victoria, where he serves on the Petrie Fellowship Committee. He became a mentor for D. Frenette (U. Prince Edward Island), recipient of an NRC Women in Engineering and Science award. Hesser was appointed by NRC President Carty to the Council’s Human Resources Promotions Committee. Within HIA, Hesser served on the Building, Visitor Centre and Management Committees, and co-chaired the Safety and Health Committee as the management representative required by collective agreements.

Hesser continued his efforts in public outreach through the British Columbia “Scientists in the Schools” program,

often with his wife, Betty. Activities included a week-long visit to nine schools in northern B.C., with 17 presentations to 750 students, in addition to an AAS Shapley Lecture at Northern Lights College in Dawson Creek. He also appeared on local TV describing the facilities upgrades initiated at the Observatory and reviewed HIA for the Vancouver Island Advanced Technology Centre, and for various community groups.

Hutchings continued as chair of the CFHT Scientific Advisory Committee (SAC). Highlights include agreement on MegaPrime survey programs, formation of a survey working group, and agreement on future participation by non-CFHT communities.

Hutchings serves as Canadian FUSE project scientist, and served on the FUSE Observers Advisory Committee. Hutchings continued to supervise the contracts and work of the two Canadian FUSE support astronomers at Johns Hopkins U. through an adjunct appointment at U. Victoria. There has been significant news media interest in the equipment and FUSE in general. Hutchings participated in an AAS press conference in Atlanta on early FUSE science results.

Hutchings served on a HST cycle 9 review panel, and joined the NGST Ad-hoc Astronomy Working Group. For a contract with CSA led by Hickson (U. British Columbia), Hutchings, Murowinski, and Morbey worked on the NGST visible imager instrument study. Hutchings supervised the NGST data simulation work by Steinbring (U. Victoria).

Hutchings serves on the organizing committee for a QSO imaging workshop for 2001 January. He also continues as mentor for several WES students, and coordinates student programs for HIA Victoria.

Morris continued as a member of the Canadian and the international Gemini Science Steering Committees, the Canadian NGST Science Steering Committee and as chair of the CASCA Optical and Infrared Advisory Committee. He is also a member of the Long-Range Planning Panel, which produced a plan for all Canadian Astronomy for the period through to 2015. He has joined the James Clerk Maxwell Telescope Time Allocation Committee, continued as Project Scientist for the Gemini Adaptive Optics System (Altair), and served as the Canadian Science Lead for the CSA-funded study of an Imaging Fourier Transform Spectrometer study for NGST.

Morris acted as supervisor for Mike Balogh (U. Victoria) and Scott Chapman (U. British Columbia), each of whom completed his Ph.D. during this period.

Roberts served on the Preliminary Design Review for the IMACS instrument for the Magellan Telescope project, and participated in the AURA Workshop on the Maximum Aperture Telescope (MAXAT), where he served on the Structures Sub-Group.

Schade visited Chile to promote Chilean participation in the Gemini science archive. During his visit he gave talks at CONICYT, U. Chile, and U. Catolica, and had discussions with astronomers at both universities. He attended a meeting in Paris in June 1999 for TERAPIX discussions. He also supervised three WES and co-op students reducing the data and preparing for the archive of CNOC I data. Schade spoke to 80 members of the PROBUS Club in May.

Stetson was a Visiting Lecturer at the Dipartimento di Astronomia, Università di Padova, 1999 October–December. He served as a member of the Editorial Board of the series “Cambridge Observing Handbooks for Research Astronomers” (Cambridge University Press). With Schade, he participated in the Paris TERAPIX discussions in 1999 June. In December, he served on one of the three review panels for the first-ever joint NASA-NSF Announcement of Opportunity, for Space Interferometry Mission preparatory science. He continues as an adjunct professor at U. Victoria.

As a guest of the Anglo-Australian Observatory, Stilburn presented two lectures, “Solutions to Some Design Challenges in the Gemini Multi-Object Spectrograph,” and “Development of a New Antireflection Coating Technology at DAO.” He also lectured on “Instrument Design at the DAO” to the Astronomy Department at U. New South Wales during his November visit to Australia.

Van den Bergh was invited to present the R. M. Petrie Prize Lecture at CASCA’s 1999 Annual General Meeting. He also completed his three-year term on the NOAO Galactic astronomy time allocation committee, and continues as an adjunct professor at U. Victoria.

Van Zee presented invited colloquia on her dwarf galaxy research at U. Massachusetts, U. British Columbia, and U. Washington.

At the invitation of ESO, Véran spent a month in Santiago as a visiting scientist in 1999 December. He is a member of the California-based Center for Adaptive Optics, which obtained NSF funding in summer 1999.

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