

**National Research Council of Canada**  
**Herzberg Institute of Astrophysics**  
**Dominion Astrophysical Observatory**  
*5071 West Saanich Road, Victoria, BC, Canada V8X 4M6*

This report covers the period from 1 April 1995 through 31 March 1996.

## 1. HIGHLIGHTS

Van den Bergh, Abraham (Cambridge U.) and collaborators have found that few spiral galaxies had formed at the mean epoch of the Hubble Deep Field: barred spirals are poorly represented, and the absence of grand-design spirals is particularly striking. Interacting, merging and merged galaxies are strongly represented in the Hubble Deep field.

The Canada-France Redshift Survey project, led by Crampton, Lilly (U. Toronto), Hammer and Le Fevre (Obs. Paris-Meudon), has established a number of quantitative indices of galaxy evolution over the lookback time established in their sample of 591 redshifts of median value 0.56.

Collaborators in the Canadian Network for Observational Cosmology have determined a cosmological density parameter from the CNOC cluster project of  $\Omega_0 = 0.16 \pm 0.04$ .

Marzke and da Costa (ESO) have shown that both local and distant luminosity functions for early-type galaxies are relatively flat at the faint end. Their result strengthens the notion that such galaxies have evolved very little over the past few billion years.

West (Saint Mary's U.), Côté, Jones (CfA), Forman (CfA) and Marzke have suggested that some centrally dominant galaxies in rich clusters may have inherited their anomalously rich globular cluster systems from a proposed intracuster globular cluster population.

Studt (U. Hamburg) classified ROSAT-selected X-ray galaxies by photometry and spectroscopy from the 1.8-m Plaskett telescope. Most of the ellipticals in the sample show no emission lines, while the spirals are dominantly Seyfert-1 galaxies.

A large collaboration including Hesser, Stetson and van den Bergh have re-examined the age-metallicity and age-Galactocentric distance relations for the 36 globular clusters with the most reliable age data. They conclude that within this sample there is no statistically significant age range or age gradient, nor is there evidence for a metallicity gradient in the Galactic halo.

From a 15-year velocity study of subgiant CH stars, McClure has shown that all these stars are binaries; they appear to be the precursors of Barium stars, as hypothesized by Luck and Bond.

Bohlender (CFHT) has demonstrated Ca II K line variability in two  $\lambda$  Bootis stars from detailed spectroscopic monitoring with the 1.2-m telescope. This may represent active accretion of circumstellar material occurring in these stars.

Balam (U. Victoria) and Aikman reported 1192 astrometric positions to the Minor Planet Center during the year.

The Canadian Astronomy Data Centre (CADAC) has re-

leased a Web-based system for the distribution of archival HST data automatically recalibrated with the most current standards.

PUEO, the Adaptive Optics Bonnette (AOB) for CFHT, underwent final testing and acceptance at the close of the report year.

## 2. STAFF & VISITORS

New appointments during the year included Tim Bond as mechanical engineer, Keith Yeung as electrical engineer, and Dayle Kotturi and Jennifer Dunn both to computer scientist positions. Tammy Smecker-Hane completed her Research Associateship, and left for an assistant professorship at the University of California at Irvine. Jes Jessen retired in September 1995, and in December Stephen Morris retired after some 33 years of service.

Temporary appointments were held during the year by Jennifer Brown, Diana Chaytor, Steve Cockayne, Janet Currie, Murray Davis, Eric Eisenhuth, Meghan Gray, Sharon Hanna, Tim Hardy, Chad Hogan, Jennifer Medlock, Aneela Nayani, Lara Phillips, Robert Ross, Joanne Rosvick, Glen Rutledge, Arlene Whetter and Paul Wierenga.

Alan Batten and Bev Oke continued as guest workers at the Observatory for the full year. Extended periods of sabbatical leave were taken at the DAO by Nick Suntzeff (CTIO), Nam-Kyu Park (Korean Astronomical Observatory), Tom Ingerson (CTIO) and Arnold Heiser (Vanderbilt U.). In November 1995, Young-Jong Sohn commenced a one year postdoctoral position supported by the Korean Science and Engineering Foundation. Other guest workers during the year were A. Cowley (Arizona State U.), J. Nemeč (International Statistics & Research Corp.) and C. Perry (Louisiana State U.).

Short working visits to DAO were also made by S. Adelman (The Citadel), R. Carlberg (U. Toronto), M. Geller (CfA), A. Gulliver (Brandon U.), R. Ivison (Royal Obs. Edinburgh), S. Kenyon (CfA), Y. Kumai (Nagoya U.), A.G.D. Philip (Union College), B. Pirenne (ST-ECF), D. Rawson (Australian National U.), A. Saha (STScI), N. Silbermann (IPAC CalTech) and R. Weymann (Carnegie Obs.).

## 3. COSMOLOGY, QUASARS, GALAXIES

Van den Bergh, in collaboration with Abraham (Cambridge U.) and other colleagues, has classified galaxies in the Hubble Deep Field (HDF) and the Medium Deep Survey (MDS), both of which have been observed with the Hubble Space Telescope (HST). Intercomparison of classifications in the HDF, MDS and in the Shapley Ames Catalog (SAC) show some remarkable differences as follows: (1) The number of interacting galaxies increases slightly between the present (SAC) and MDS eras, and increases strongly between the MDS and HDF epochs. (2) The frequency of

barred spirals decreases precipitously as one proceeds from the SAC through the MDS to the HDF eras. (3) Early-type galaxies are present at all epochs. However, late-type spirals are much less common in the HDF than they are in the MDS and SAC. This suggests that most late-type spirals had not yet been assembled during the HDF era. This conjecture is supported by the large number of mergers that are seen in the HDF. The absence of grand-design spirals in the HDF is particularly striking.

The classification of galaxy images by human eyes and by artificial neural networks was compared by Lahav (Cambridge U.), van den Bergh and others. Niam (Cambridge U.) and van den Bergh *et al.* also compared machine and ‘expert’ classifications of galaxy morphology. The conclusions of these studies are that computer-driven classification techniques are now competitive with visual classification by expert morphologists.

Van den Bergh has also presented a preliminary classification system for late-type galaxies that is based on inspection of the prints of the Carnegie Atlas of Galaxies. Systems that exhibit small bright central bulges or disks are found to, on average, have earlier types and higher luminosities than do galaxies that do not contain nuclei.

Van den Bergh has continued his studies of the extragalactic distance scale. From Cepheid distances to four spiral galaxies in the Virgo region, he finds that the Hubble parameter  $H_0 = 81 \pm 8 \text{ km s}^{-1} \text{ Mpc}^{-1}$ .

Van den Bergh finds that the specific globular cluster frequency is the same in giant and in dwarf elliptical galaxies. This result poses a challenge for the hypothesis that the high globular cluster frequency in ellipticals is due to cluster formation during collisions.

The Canada-France Redshift Survey (CFRS) has resulted in a long series of papers in the *Astrophysical Journal* by Crampton, Lilly (U. Toronto) Hammer and Le Fevre (Obs. Paris-Meudon). Their sample consists of 943 spectra of very faint  $17.5 \leq I_{AB} \leq 22.5$  objects in five separate fields taken with the CFHT MOS spectrograph. Analyses of the 591 galaxies with secure redshifts (median  $\langle z \rangle = 0.56$ ) demonstrates that: 1) The luminosity function of red galaxies shows very little change in either number density or luminosity over the entire redshift range  $0 < z < 1$ , but the blue galaxies show substantial evolution at  $z > 0.5$ . 2) A complete sample of the optical counterparts of  $\mu\text{Jy}$  radio sources reveals three populations dominating the  $\mu\text{Jy}$  radio counts:  $z > 0.7$  early-type galaxies with radio emission powered by an AGN, intermediate redshift post-starburst galaxies, and lower redshift blue emission-line objects. 3) HST *B* and *I* images of 32 CFRS galaxies with  $0.5 < z < 1.2$  show two effects which must be responsible for much of the observed evolution of the luminosity function of blue galaxies. Of galaxies bluer than present-day *Sb*, one-third are “blue nucleated galaxies,” and half are late-type galaxies with disks which are significantly brighter than normal galaxies at  $z=0$ . 4) The surface density of quasars with  $I_{AB} \leq 22.5$  discovered in the CFRS,  $200_{-80}^{+120} \text{ deg}^{-2}$  is the highest yet measured, but is in good agreement with extrapolations from other faint surveys. 5) The comoving luminosity density of the Universe increases as  $(1+z)^{2.1 \pm 0.5}$  at  $1 \mu\text{m}$ , as  $(1+z)^{2.7 \pm 0.5}$  at  $4400$

$\text{\AA}$  and as  $(1+z)^{3.9 \pm 0.75}$  at  $2800 \text{\AA}$ , for a ( $q_0=0.5, \Omega=1.0$ ) cosmological model. This implies a rapid decline in the star-formation rate and in the *physical* luminosity density at short wavelengths (by two orders of magnitude) since  $z \sim 1.6$ . The slope of the projected two-point correlation function of galaxies is the same at high redshift as locally, but the amplitude at  $z \sim 0.6$  is a factor of 10 times lower. HST has shown four images of a background quasar lensed by the elliptical galaxy CFRS14.1311; spectral features observed in the CFRS study indicate  $z = 0.81$  for the elliptical galaxy and  $z = 3.4$  for the lensed quasar.

The Canadian Network for Observational Cosmology (CNOC), whose principal investigator is Ray Carlberg (U. Toronto) with the involvement of Hesser, Hutchings, Marzke and Simon Morris at DAO, plus many other collaborators at other institutions, has completed its first measurement of the cosmological density parameter  $\Omega$ . Papers now in publication detail the determination of the value  $\Omega_0 = 0.16 \pm 0.04$  from the CNOC cluster galaxy project; cluster mass-to-light ratio profiles are also determined from these data. A paper using the CNOC cluster data to constrain the  $\sigma_8$  parameter is in preparation. Observations and data reduction for the follow-up CNOC project on field galaxies have now been completed.

From the CNOC galaxy cluster database, Abraham *et al.* (including DAO authors Smecker-Hane, Hutchings and Morris) have completed analysis of the galaxy population of the rich cluster A2390, at  $z=0.23$ . The data reveal radial gradients of the galaxy population and their stellar content which suggest that star-formation is truncated as galaxies are accreted continuously by the cluster. A similar analysis is underway of the cluster 1621+246 by Hutchings, Morris, and Abraham. This cluster is at higher redshift ( $z=0.43$ ), and the stellar populations are younger and the cluster structure shows an earlier stage of a similar evolution. Additional data have been obtained with the VLA, HST, CFHT, and Rosat, and are being analysed by Hutchings, Morris and Gower (U. Victoria). Further spectra of A2390 will be obtained with Hutchings’ observing time with the HST STIS instrument. Hutchings and Morris are co-investigators in a successful HST proposal by Schade (U. Toronto) to observe moderate redshift clusters.

Simon Morris and Davidge have obtained further data using the CFHT SIS spectrograph to study the evolution in velocity dispersion and colours with redshift of the brightest cluster galaxies in an X-ray selected sample of clusters.

Marzke, Geller (CfA), da Costa (ESO) and Huchra (CfA) analyzed the pairwise velocity distribution of galaxies in the CfA and SSRS2 redshift surveys. Modeling the anisotropy in the redshift-space correlation function, they find that the pairwise velocity dispersion is significantly larger than indicated by earlier measurements. This result partially alleviates a strong conflict between the observations and currently popular models of large-scale structure. Marzke and Geller also performed a similar analysis of the Century Survey, a new redshift survey to  $R \sim 16.4$  (Geller *et al.* 1996). They found a strikingly similar result for the pairwise velocity dispersion.

Kenyon (CfA), Marzke and Geller are compiling H mag-

nitudes of  $\sim 1000$  galaxies to determine the infrared luminosity function of nearby galaxies. The galaxies are drawn from the Century Survey. These observations will provide a benchmark for the interpretation of deep counts of galaxies in the near infrared.

Marzke and da Costa found from the Southern Sky Redshift Survey (da Costa *et al.* 1994) that the local luminosity function of galaxies bluer than a typical Sbc is quite steep at the faint end ( $\alpha = -1.5$ ), while the red galaxy luminosity function declines slightly at the faint end ( $\alpha = -0.7$ ). The local luminosity functions are thus quite similar to those measured by the CFRS team at higher redshifts, which suggests that the *shapes* of the individual blue and red luminosity functions do not evolve significantly at  $z \leq 1$ .

Marzke and da Costa also analyzed the dependence of the local luminosity function on galaxy morphology. The luminosity functions of both E/S0 galaxies and spirals are flat at the faint end, contradicting earlier analyses (e.g. Loveday *et al.* 1992, Efstathiou, Ellis and Peterson 1988). These new observations support the claim of Marzke *et al.* (1994) that the paucity of early-type galaxies in the Stromlo-APM luminosity function may be caused by incomplete galaxy classification. This result also strengthens the conclusions from deep galaxy counts that early-type galaxies have evolved very little over the past several billion years.

Oke, Postman (STScI), Christensen (STScI), Lubin (Princeton U.), Gunn (Princeton U.), Hoessel (U. Wisconsin) and Schneider (Penn State U.) have completed a catalog of 79 clusters of galaxies selected in the red and near infrared using the Hale 5-m telescope. A matched filter algorithm was used to identify the clusters in the sampled fields. The clusters cover a range in redshift of 0.2 to 1.2 based on the redshift estimates derived from the cluster fitting algorithms. The cumulative surface density of clusters with density class greater than one is five times that extrapolated from the Abell cluster catalogue. A supplementary list of 28 additional possible clusters is included. Finding charts are provided for all the clusters.

Oke and Postman (STScI) are carrying out a study of nine cluster candidates, all of which should have redshifts in the range from 0.6 to 1.2, using the 10-m Keck Telescope on Mauna Kea. Observations include broad-band CCD photometry at B, V, R and I, and low-resolution spectra of up to 120 candidate galaxies per cluster. In addition, some of the clusters are being observed with the Hubble Space Telescope. Ground based observations have been completed for six of the clusters and two of them have been observed with HST. In the five clusters for which redshifts have been derived, clusters are indeed found with redshifts up to at least 1.05. For the clusters with  $z < 1$ , there are still very red elliptical-like galaxies present. The fraction of old red galaxies varies from 20 to 100 percent with little dependence on their redshift. About 70 percent of the spectroscopically observed galaxies have emission lines indicating continuing star formation.

West (Saint Mary's U.), Côté, Jones (CfA), Forman (CfA) and Marzke proposed a model to explain the origin of the anomalously large globular cluster systems surrounding some, but not all, centrally dominant galaxies. According to

their model, those galaxies which are located near the gravitational potential well of the host cluster have inherited an additional population of *intracluster globular clusters* – objects which may have either formed *in situ*, or have originated as tidally stripped debris from galaxy interactions and mergers. Observations designed to test the model are underway, in collaboration with Pritchett (U. Victoria).

Côté, Oke and Secker (Washington State U.) have begun a spectroscopic survey of dwarf galaxies in the Coma cluster using the Keck telescope. Ages, abundances and radial velocities will be derived from the spectra, and will be used to assess the role played by environment in the evolution of these low-luminosity galaxies.

Simon Morris, Weymann (Carnegie Obs.) and Jannuzi (Princeton U.) have made CFHT observations using MOS (multi-object spectrograph) of over 400 galaxies located near the lines of sight to quasars. All these quasars have ultraviolet spectra observed by HST, thus allowing their absorption features to be compared with the galaxy redshifts. This study will provide a large body of data to investigate the relationship between galaxies and the low column-density hydrogen absorption seen against quasars.

Hutchings and Gower (U. Victoria) completed analysis of quasar radio structure in clusters from VLA maps of a sample of more than 50. Lobe-dominated sources are found in denser clusters, and compact sources in lower density clusters. The QSO clusters have fewer background sources than very rich clusters, suggesting a lensing effect. The maps are being published in collaboration with Ellingson (U. Colorado).

Hutchings and colleagues at STScI and JPL have HST cycle 6 observing time for imaging of a sample of high redshift quasars. These data will be complemented by, and combined with, narrow bandpass images taken with PUEO, the adaptive optics bonnet system at CFHT.

Hutchings and Neff (GSFC) obtained CFHT near-infrared images of a sample of low redshift quasars, and some high redshift ones with an excess of galaxy companions. The near-infrared properties of the host galaxies and companions will be studied with the data, currently being processed partly in collaboration with Davidge.

Observations of quasar host galaxies with PUEO at CFHT are planned by Hutchings, Crampton, and Morris. Hutchings and Morris are participating in monitoring programs of active galactic nuclei with IUE, HST, and ground-based telescopes. Hutchings has obtained HST observing time to study radio galaxies in collaboration with Baum and others (STScI). Hutchings and Crampton are obtaining spectra of high redshift QSO companions with CFHT to study their properties and dynamics.

Sohn and Davidge used CCD images in V, R, I bands with sub-arcsec spatial resolution to investigate the bright evolved stellar content of nearby galaxies including NGC 628, NGC 672, and NGC 925. Their first paper from this study was confined to NGC 628. For this galaxy, they used previous photometric surveys to identify HII regions, the majority of which have non-stellar colors. After removing these objects from the sample,  $\sim 310$  stellar objects remained. The  $(V-R, R-I)$  diagram of these objects suggests that the ma-

majority have spectral types F, G, and K, indicating that residual contamination from non-stellar objects is negligible. Comparisons with theoretical evolutionary tracks indicate that the majority of supergiants in the field have progenitor masses below  $25 M_{\odot}$ . The luminosity functions in all three band passes follow power laws, with the exponent in  $V = 0.80 \pm 0.12$ , in good agreement with what is seen in other galaxies. The brightest red supergiants occur at  $V \sim 21.0$ , from which they derive a distance modulus of 29.3.

Stedt (U. Hamburg) made Plaskett 1.8-m telescope observations of 25 galaxies at 22 ROSAT X-ray positions, for which the origin of the X-ray radiation was unclear. These galaxies are optically bright ( $B < 16$ ) and presumably near ( $z < 0.1$ ). Through photometry and spectroscopy, he classified these galaxies and determined their redshifts. In most of the cases he found ellipticals with no emission lines, and spirals which could be classified as Sy-1 galaxies. Stedt also observed three galaxy-pairs, which will be proposed to be observed with the ROSAT High Resolution Imager, in order to determine the exact location of the X-ray sources.

Hutchings and collaborators within the HST STIS team are continuing investigations of knots of star-formation in different galaxy environments, combining CFHT and HST observations to optimize both sensitivity and spatial resolution.

Hutchings, Bianchi (STScI), Massey (NOAO) and collaborators continue their spectroscopic studies of hot stars in the Local Group galaxies M31 and M33. HST and 4-m ground-based spectra allow modelling of the stellar winds from these stars, and their comparison with other hot stars within Local Group galaxies. The new data are increasing the spatial sampling, and also include the WR stars. HST ultraviolet spectra of faint reddened stars have been used to derive extinction curves for the Galactic halo and the disk of M31: these extinction laws differ from each other. A large investigation has been completed of the hot star population of M33, based on ground-based spectra, and HST visual images and UIT ultraviolet images.

Hutchings and Crampton have continued their collaboration with Cowley and Schmidtke (Arizona State U.) on supersoft X-ray sources in the LMC and SMC. New X-ray data, optical photometry, and 4-m telescope spectra are used to identify the sources and study their evolutionary status. It remains unclear whether these sources are all surface-burning white dwarfs: the inclusion of other types of object may be indicated by the presence of high velocity jets. One candidate source is found to be the hottest known PG1159-type star.

Stetson and Hesser obtained extensive V and I CCD photometry of the Fornax dwarf spheroidal galaxy at the CTIO 1.5-m in December, 1995 as part of a systematic study of dSphs with Smecker-Hane (U. California Irvine). ALLFRAME reductions indicate that star formation occurred over a large fraction of the galaxy's lifetime, and that some stars have formed very recently. This contrasts dramatically with the clear pattern of episodic star formation in the Carina system, for which analysis of the deep photometry was nearing completion at the close of the report year.

Stetson continued his participation in the HST Key

Project on the extragalactic distance scale, and spent much of the year analyzing photometric properties of the WFPC2 cameras. From careful comparison between ground-based and HST data for outer halo globular clusters, among other objects, he demonstrated the existence of subtle non-linearities affecting photometric integrity at the few percent levels. The Space Telescope Science Institute operations team has adopted as a standard field the NGC 2419 regions observed by Stetson and collaborators for their study of the outer halo of the Galaxy.

#### 4. THE GALAXY & ITS CLUSTERS

Stetson led the ALLFRAME reduction of HST images obtained by a large team of Canadian and American researchers that includes Hesser (PI), McClure and van den Bergh. Their data are for globular clusters in the outer halo of the Milky Way: Pal 3, Pal 4 and NGC 2419 were observed in Cycle 4, and Eridanus in Cycle 5. When Cycle 6 observations are completed for AM 1 and Pal 14, V (F555W) and I (F814W) color-magnitude diagrams for all the clusters whose main sequence turnoffs are beyond accurate determination with ground-based telescopes will have been measured. Preliminary analysis led by Harris (McMaster U.) and Bolte (Lick Obs.) shows that NGC 2419's ( $R_{gc} \sim 100$  Kpc) color-magnitude diagram is indistinguishable from that of M92 ( $R_{gc} \sim 10$  Kpc), which suggests that a global star formation event occurred over a vast volume in the proto-Galaxy.

With VandenBerg (U. Victoria), Stetson has obtained and analyzed CCD photometry for Galactic globular clusters at the CFHT. Among the goals of the program is highly differential photometry of clusters to enable similarities and differences to be identified. M3 and M13, the classic Northern hemisphere pair of 'second parameter' clusters, appear to differ in age by less than one gigayear. These results were presented in an invited review at the triennial CFHT Users Meeting in Lyon, France.

Côté, Welch (McMaster U.) and Stetson have finished the photometric portion of their phase-space survey of the inner Galaxy. Spectroscopic observations with the WIYN telescope are pending. Once completed, the survey will place limits on the role played by mergers in the formation and evolution of the Galactic halo and bulge.

Richer, Fahlman, Holland (all U. British Columbia), Harris (McMaster U.), Bell (U. Maryland), Bolte (Lick Obs.), Bond (STScI), Hesser, Stetson and van den Bergh (DAO), and Pryor (Rutgers U.) critically examined the age-metallicity and age-Galactocentric distance relations for the 36 globular clusters with the most reliable age data. They conclude that clusters at all metallicities in the Milky Way appear to be the same age, and find no evidence for a statistically significant age or metallicity gradient in the Galactic halo.

Rutledge, Hesser, Stetson, Mateo (U. Michigan), Simard (U. Victoria), Bolte (Lick Obs.), Friel (Maria Mitchell Obs.) and Copin (ENS de Lyon) completed reduction of the 2640 CCD spectra with resolution  $4\text{\AA}$  in the 7250-9000  $\text{\AA}$  region for 976 stars lying near the red giant branches in color-magnitude diagrams of 52 Galactic globular clusters. Radial

velocities of  $16 \text{ km s}^{-1}$  accuracy per star determined from the spectra were combined with other criteria to assess quantitative membership probabilities. Equivalent widths of the infrared calcium triplet yield a relative metal abundance ranking of improved precision. In collaboration with Irwin and Larson (U. Victoria), spectrum synthesis calculations for the triplet are being performed in order to understand the relative contributions of stellar atmosphere and Galactic formation physics.

Zurek and Saffer (STScI), Hesser and Vandenberg (U. Victoria) obtained spectroscopic observations with the CTIO 4-m Blanco Telescope and Argus spectrograph in December 1995 to study the chemical properties of horizontal branch (HB) and red giant branch (RGB) stars in the bimodal HB clusters, NGC 1851 and NGC 2808. Approximately 180 and 130 stars were observed in the two clusters, respectively; the samples are evenly split between HB and RGB stars. A comparison field was observed in 47 Tucanae. Data analysis is underway.

Gim (U. Victoria), working with Hesser, McClure, Stetson, and Vandenberg (U. Victoria) is studying the rich, old open cluster NGC 7789 for his M.Sc. thesis. New V, I colour-magnitude diagrams from data taken by Zurek (STScI) and by Gim using the 1.8-m Plaskett Telescope cover about  $40' \times 50'$ , which is about ten times that of the largest previous survey by Burbidge and Sandage (1958). The limiting magnitude for the 600 second exposures is about  $V=21.5$ . Potential new giant stars have been identified, and velocities measured with the radial velocity scanner on the 1.2-m telescope. A new epoch of velocity data for a sample of some 80 red giants has been added to the data accumulated by McClure and Hesser since 1979. The binary frequency will be determined, as will the spatial distribution of the binaries.

Côté and Fischer (U. Michigan) have completed their search for main-sequence spectroscopic binaries in the globular cluster M4. Based on multiple radial velocities for 33 faint dwarfs, they have deduced a main sequence binary fraction which is comparable to that among F and G dwarfs in the solar neighborhood. This result, coupled with the very low binary fraction found for the more massive cluster M22 by Côté, Pryor (Rutgers U.), McClure, Fletcher and Hesser, has been interpreted as evidence for the destruction of wide binaries in globular clusters through stellar encounters.

Van den Bergh has used the luminosities and tidal radii of globular clusters to derive their perigalactic distances. The technique is not considered to be reliable for globular clusters with collapsed cores. It is found, however, that the globular cluster radii correlate more strongly with their perigalactic distances than they do with their present Galactocentric distances.

## 5. ERUPTIVE & VARIABLE STARS

Balam (U. Victoria) has published a light curve of supernova 1996C in MCG+08-25-47, a galaxy at redshift  $z=0.027$ . This type Ia supernova was observed from 9 days past maximum with the 1.8-m Plaskett telescope.

Van den Bergh has proposed a new way of deriving the distances of supernovae of Type Ia that is independent of

interstellar absorption. In conjunction with present theories of SNe Ia explosions, this technique returns low values of the Hubble parameter, which conflict with the higher values derived from the Cepheid distance scale. Either the Cepheid distances are wrong, or supernova theory gives too high an explosion energy or the wrong SNe Ia radii.

Younger continued the compilation of catalogs of all published photoelectric U, B, V observations of novae and supernovae; the compilation of novae observations is now completed.

Simultaneous photometric and spectroscopic observations by Crampton, Hutchings, Cowley, Schmidtke (Arizona State U.) and O'Donoghue and Harrop-Allin (both U. Cape Town) of the optical counterpart of RX J0513.9-6951, a "super-soft" X-ray source in the LMC, suggest a binary period of 0<sup>d</sup>.76 and relatively massive compact object. Unusual high velocity ( $4000 \text{ km s}^{-1}$ ) emission lines are interpreted as being due to bipolar outflows or jets.

During the initial part of his leave at the DAO, Heiser (Vanderbilt U.) completed an analysis of observations obtained with the Vanderbilt 41-cm automated photometric telescope (APT) of the long period Cepheid S Vul. A period of 68.385 days was found from these observations, and comparison with previous photoelectric data indicates a period decrease of about 0.41 days over nearly 28 years. Cepheid evolution models were used to locate S Vul in the instability strip, from which an  $M_v = -6.41$  was determined. He has also completed the analysis of photoelectric UBV and uvby observations of U Com, an RR Lyrae star with a pre-maximum bump. The refined period of this star is 0.29273861 days. BV photometry of the eclipsing binary V578 Mon, obtained with the Vanderbilt APT during 1994 and 1995, has shown that the primary minimum is about 0.01 to 0.02 magnitude deeper than the secondary, and that the system does indicate apsidal motion. A period of 2.408466 days has been found using these data with photometry obtained at both the Dyer Observatory (Vanderbilt U.) and at the KPNO from 1962 through 1981. The secondary minimum of the star during 1994/5 occurs at a phase of 0.55.

Vinko (York U. and Jate University, Hungary) and Nemec are searching for variable blue stragglers in the globular clusters M71 and NGC 2419, based on CCD observations of the clusters with the 1.8-m Plaskett telescope.

## 6. BINARY STARS

Batten published an invited review for *Reports on Progress in Physics* entitled "Stellar Evolution in Binary Systems."

McClure, in collaboration with U. Victoria Co-op student Chad Hogan, continued radial velocity observations of subgiant CH stars and early R-type carbon stars, using the 1.2-m radial velocity scanner. These observations have been ongoing for approximately 15 years now, and definitive conclusions as to the binary nature of these stars can now be drawn. In a sample of 10 sgCH stars, eight show variable radial velocities indicating duplicity, and a further one is a possible variable. It is reasonable to conclude that all sgCH stars are binaries, and that Luck and Bond's suggestion that they are the precursors of Barium stars is correct.

In the sample of 38 carbon stars observed at DAO by McClure, six are classified as N stars and a further seven as R5-R8. Many of these show scatter in their velocities larger than the observational errors, but little evidence for systematic variations due to duplicity. One star is most likely a CH star, and it is definitely a binary. The remaining 24 stars are classified R0-R4, and none show velocity variations. This is surprising, considering that in a sample of 39 normal K-giant stars observed with the same instrument over a similar period of time, five show easily detected velocity-variations.

Graham Hill has continued observation and analysis of (mostly) early-type stars in the long-term program of determining fundamental stellar parameters. Observations are continuing slowly, since the objects remaining are faint ( $V \sim 8$  mag) for the 1.2-m coude and they are largely confined to the more cloudy winter sky.

Scarfe (U. Victoria) has continued to obtain radial velocity observations of binary and multiple stars with the 1.2-m telescope, chiefly with the radial velocity spectrometer (RVS), although photographic observations are still obtained for a small number of objects for which more accurate data over a long period are required. He also continues to obtain observations of IAU standard velocity stars, again mainly with the RVS. Several new spectroscopic binaries among the stars in the Bright Star Catalogue Extension have been identified and are being followed to determine orbital parameters. The bright K-type star  $\gamma$  Canis Minoris has long been known as a single-lined spectroscopic binary. While collecting RVS observations for the purpose of improving the accuracy of the orbit determination, Scarfe has detected the presence of a weak feature attributable to the companion star, and has obtained orbital elements for both components of the system. The mass ratio is not far from unity, and the system should be resolvable by long-baseline interferometry. The system of HD 483 has been analysed jointly by Scarfe and R.F. Griffin (Cambridge U.), and found to be an eccentric double-lined object of fairly short period. Scarfe and Barlow (U. Victoria) have nearly completed an analysis of the system of 12 Persei based on published speckle interferometry and a new set of DAO coude radial velocity data.

Grant Hill (U. de Montréal) continues to observe WR+O binaries with the 1.8-m Plaskett telescope. Moderate resolution, high signal-to-noise spectra are being obtained to search for wind-wind collision effects, and to obtain improved orbits. Many of the stars being studied are long period systems for which phase coverage is nearing completion.

## 7. STELLAR SPECTRA

Adelman (The Citadel) continued studies of sharp-lined normal and peculiar main-sequence B, A, and F stars based primarily on  $2.4 \text{ \AA mm}^{-1}$  observations obtained with the 1.2-m McKellar telescope. Fine analyses of the spectroscopic binaries with HgMn star primaries  $\alpha$  And and 46 Dra are in progress with Ryabchikova (Russian Academy of Sciences). Such stars provide tests of the theories of the non-magnetic chemically peculiar stars, as these stars presumably are of the same age and had the same initial elemental abundances as their companions. Analyses of the superficially normal stars B-type stars 8 Cyg, 22 Cyg,  $\eta$  Lyr, and 22 Dra are nearing

completion. A comparison of the line profiles of Reticon spectrograms taken with the DAO coude spectrograph and of CCD spectrograms obtained with the coude feed telescope at Kitt Peak National Observatory shows that they agreed quite well allowing for resolution and noise. The amount of scattered light does not differ by more than 1%.

Adelman, Gulliver (Brandon U.), Graham Hill and Perry (Louisiana State U.) continue to obtain 1.2-m observations of the H $\gamma$  profiles of B, A, and F type stars. They will compare these data and optical and ultraviolet spectrophotometry with the predictions of Kurucz's ATLAS9 model atmospheres to derive effective temperatures and surface gravities using the spectrophotometric fitting program STELLAR. As a continuation of this program, Hill has extended his software program ROTATION to analyze hydrogen line profiles and to include microturbulent velocity as an unknown. As it stands, ROTATION can work with combined spectrophotometric and line profile data to determine effective temperature, surface gravity and microturbulent velocity. Gulliver and Adelman are well along in extending the database of theoretical atmospheres in temperature from 7500 to 20000 K, and in [Fe/H] from -2 to +1.

Philip (Union College), Aikman and Adelman continue their program of spectroscopic observations of field horizontal-branch stars with the 1.2-m McKellar telescope. Accurate H $\gamma$  profiles are being observed in order to derive temperatures and gravities from the Hill's STELLAR software as described above.

Côté, Hill, Gulliver (Brandon U.) and Adelman (The Citadel) have begun a program to measure masses and helium abundances for horizontal branch stars in the second parameter pair of globular clusters M3 and M13 using the MOS spectrograph on the CFHT. These data will be used to test the possibility that mass loss and/or helium abundance are responsible for the disparate horizontal branch morphologies of these two clusters.

Grant Hill (U. de Montréal) has started a program of observing WN8 stars with the 1.8-m Plaskett Telescope. Among the 'late-type' WN stars, these stars consistently reveal the highest degree of intrinsic variability among all WR stars, whether in photometry, polarimetry, or spectroscopy. Until now, spectroscopy has not been extensive enough to differentiate between a number of candidate mechanisms for these variations. Blue-violet spectra obtained at the DAO, yellow-red spectra obtained at Observatoire du Mont Mégantic, and photometry obtained at San Pedro Martir are currently being reduced.

Andrew Walker (U. British Columbia) and collaborator Kennelly (High Altitude Obs.) obtained time-series observations of the rapidly rotating  $\delta$  Scuti star  $\tau$  Peg using the 1.2-m telescope. The observations were part of an ongoing series of international, multisite campaigns to study in detail the oscillation spectra of selected stellar seismology candidates.

Wallerstein and Zucker (both U. Washington) used the 1.2-m telescope, long camera and long CCD to observe M supergiants in  $\eta$  and  $\chi$  Persei for their lithium abundance using both the 6707 and 8126  $\text{\AA}$  lines. A number of SC type stars were also observed at several wavelengths as part of an

analysis of their chemical abundances to be carried out in cooperation with Abia (U. Granada). A special observation of the cool CH star, V Ari, was obtained in cooperation with Richichi (Arcetri Obs.), who observed its lunar occultation within a few nights of the spectroscopic observations.

Bohlender (CFHT) has carried out several investigations with the 1.2-m telescope. To attempt to provide direct support for speculation concerning the origin of the peculiar  $\lambda$  Boo stars, he has completed a search for evidence of spectrum variability in the northern members of these metal deficient objects. Recent theoretical work suggests that the  $\lambda$  Boo star phenomena is associated with a currently active accretion phase occurring in a fraction of early A stars at some point following their arrival on the main sequence. Some observational support for this idea comes from the fact that the circumstellar Ca II K and Na I D shell lines seen in some  $\lambda$  Boo stars are very similar to the strong shell lines observed in  $\beta$  Pic, an object that has well established circumstellar (and possibly protoplanetary) dust and gas disks as well as ongoing accretion episodes. It has also been proposed that  $\beta$  Pic is in fact a member of the  $\lambda$  Boo class. High-S/N, high resolution spectra of the Ca II K line of several members of the class have revealed spectral variability in two of them.

Bohlender also used the 1.2-m telescope with Yang (U. Victoria) to participate in a multisite campaign to observe the recently discovered nonradial pulsation in the  $\lambda$  Boo star HD 111604. The goal is to use the observed pulsation frequency spectrum to provide direct evidence of the evolutionary state of at least one  $\lambda$  Boo star. As noted above, current theory predicts that these objects should be very near the zero-age main sequence.

Bohlender acquired H and He line spectra of the helium-strong star  $\delta$  Ori C over a wide range of wavelengths, with the aim of searching for confirmation of a vertical stratification of the helium abundance in the photosphere of this remarkable magnetic star. Spectra extending from the Balmer jump to beyond the Ca II infrared triplet probe the photosphere at a wide range of continuum optical depths, and will permit comparison of the observed line profiles with models produced from model atmospheres with various vertical abundance profiles of H and He.

## 8. SOLAR SYSTEM

Balam (U. Victoria) and Aikman continue the astrometric monitoring of asteroid positions with the 1.8-m Plaskett telescope. The emphasis of the program is overwhelmingly on unusual and recently discovered asteroids, particularly those in Earth-approaching orbits. Additionally, asteroids which have been recorded sporadically over the past half-century or so, but never observed sufficiently to allow the assignment of a permanent designation, are sometimes observed as time and circumstance permit.

Comets are likewise monitored when time permits. The spectacular passage of C/1996 B2 Hyakutake at the close of the report year was intensively observed, with some 2000 CCD exposures taken over three successive nights at the time of closest approach to Earth. These frames are being processed to detail the near-nucleus activity in the comet.

An ongoing goal of the astrometry program is to increase the speed and volume of observational throughput. In this regard it may be noted that the number of astrometric positions reported to the Minor Planet Center during year was 1192, more than twice the number of any previous year. Also, same-night observation, reduction and reporting of our astrometry is now allowing rapid dissemination of our results through the Minor Planet Center to a worldwide network of observatories. This is most essential for the closest Earth-approachers, whose apparitions are brief and infrequent, and must be observed intensely in order to permit future recovery of these objects. The Plaskett telescope program is also complemented by observations at the Climenhaga Observatory by Balam and Tatum (U. Victoria).

## 9. DATA ARCHIVING & PROCESSING

The Canadian Astronomy Data Centre (CADC) released a World Wide Web interface and associated software package which enables users of the Hubble Space Telescope archive to perform easy on-the-fly recalibration of data downloaded from the archive. This approach provides archival researchers with HST data which have been recalibrated using the latest software and currently recommended calibration files. Until now, researchers requesting calibrated data from the archive received the 'static' data, that is the raw observations and/or data calibrated at the time of the observation. The new service uses the raw data, plus the recommended calibration files as indicated by the Calibration Database maintained by STScI, and the latest calibration software available in STSDAS, to produce freshly recalibrated data. This service automates the process that an archival researcher would follow if he or she wished to recalibrate the data in the archive for themselves. The interface lets the user search for data by object, instrument, or other parameter. It also allows the user a 'preview' look at the data, and monitors the progress of the request as it is processed by the system. Processed data can be then be retrieved by 'ftp', or sent on DAT or Exabyte tape. Information on access to the Hubble archive can be found at <http://cadcwww.hia.nrc.ca> on the internet.

Our Web pages on the internet serve increasingly as the distribution medium for preprints of the Observatory. Also included on our WWW pages are the various facility, telescope and detector manuals of interest to visiting scientists, DAO telescope schedules and projects, our annual reports, lists of DAO publications, staff lists, library information and search links. The Web pages also contain information for the interested public and links to astronomical facilities and data sources worldwide. Aikman leads the development of the Web pages, which are located at:

<http://www.hia.nrc.ca/DAO/homepage.html>

Hill continues to update the LIGHT2 and REDUCE suite of software. A recent improvement is the migration of the graphics to the PGPLOT software package.

At the close of the report year, a major rewiring of the data and voice networks serving all buildings on the Observatory site was in progress. The goal of this project is to upgrade the local area computer network and telephone infrastructure to a standard of reliability and flexibility that will be adequate for the coming decades.

## 10. DAO TELESCOPES & INSTRUMENTATION

Telescope time on the 1.8-m Plaskett telescope was allocated on 355 nights of the year, of which 20% were assigned to projects led by staff members, and 80% went to projects with non-staff persons as principal investigator. Astronomical observations were actually conducted for 1286 hours on 198 nights during the year. On 64% of the useful nights, the telescope was used in imaging mode, almost exclusively with a CCD detector, as our near-infrared PtSi array detector was unavailable for most of the reporting period due to technical problems. Saddlemeyer is investigating the acquisition of a NICMOS-based infrared detector as replacement. On the remaining 36% of observable nights, the telescope was used at the Cassegrain focus for spectroscopic observations.

Of 361 nights of scheduled time on the 1.2-m McKellar telescope, 89% were assigned to projects led by non-staff members as principal investigator, and the remaining 11% to staff-led projects. Astronomical observations with the telescope were conducted for 1505 hours on 222 nights. On 75% of these 222 nights, the mode of observation was CCD and Reticon spectroscopy at the coudé focus, with both types of detector being employed comparatively on a large number of nights. This was to ensure continuity in long-term monitoring programs formerly based on Reticon observations, but now pursued with the several CCD detectors which have supplanted the Reticon. On 22% of the usable nights, the coudé Radial Velocity Scanner was used, and the remaining 3% of nights were used mostly for engineering tests of a prototype adaptive optics system being developed by U. British Columbia.

In December 1995, the SITE-2 CCD was commissioned by Leckie (who coordinated the efforts to produce the CCD controller) and Saddlemeyer. This detector has  $1752 \times 532$  pixels of  $15 \mu$  pitch, with excellent blue sensitivity and a peak quantum efficiency of approximately 70% around  $6000\text{\AA}$ . Because of its dimensions, this CCD is used solely at the coudé spectrographs of the 1.2-m telescope, where it has replaced the Reticon. However at present, the read noise of this CCD remains high, about 40 electrons per pixel.

Saddlemeyer and Simon Morris arranged the acquisition and purchase of new 'bare CCD' guide cameras from Princeton Instruments to replace the TV guiders of the 1.8-m and 1.2-m telescopes; delivery of three such cameras occurred at the close of the report year. Sebesta designed mechanical mountings for the cameras; tests on the telescopes will begin shortly.

Hill as coordinator of the Telescopes Group (Aikman, Bond and Younger, with the strong support of Saddlemeyer of the Instrumentation Group) has overseen the smooth operation of the telescopes. Saddlemeyer continues to work on the position encoder upgrade for the 1.8-m telescope. The necessary components have all been acquired, and the mechanical mountings have been designed and fabricated. Software design is completed and is partially implemented. Younger continued refinement of the fiber optic link on the 1.2-m telescope, including fabrication of 100- and 200-micron feed fibres. Work is proceeding on providing computer controls to the arc, lamp, mirrors, *etc.*, for spectro-

scopic observations so that the data acquisition and telescope control can be integrated.

Saddlemeyer and Davis (U. Victoria co-op student) have further developed and refined the DICE (DAO Instrument Control Environment) software which is used on both telescopes. Firstly, they added an interactive plotting package for displaying spectra within DICE. Secondly, they have incorporated a distributed control system to operate remotely various devices such as focus and filter wheel when observing on the Plaskett telescope.

Hill is still working closely with local municipalities to review lighting plans for all commercial development in the area; last year he reviewed about two-dozen major construction projects. Saanich municipality has enacted a bylaw incorporating the lighting requirements we've been using. Central Saanich has adopted the same lighting standards, but has not as yet enacted a bylaw.

## 11. OTHER INSTRUMENTATION

PUEO, the Adaptive Optics Bonnette (AOB) for CFHT, underwent its final assembly, integration and testing by the DAO Instrumentation Group in May 1995. This was the culmination of the efforts of many people, including staff members Crampton, Roberts, Leckie (who wrote the software manual) and Fletcher (who completed the alignment of the internal optics). After shipment to Meudon for installation and integration with the deformable mirror, PUEO underwent acceptance tests at CFHT. It achieved a Strehl ratio of 0.5 with  $0.8''$  natural seeing in K band, while using natural guide stars as faint as 15th magnitude.

A new optical system has been installed in the the CFHT SIS spectrograph, now renamed OSIS. The new optics, based on a design by Morbey, extend the usable wavelength range to  $0.4 - 1.8\mu$ . New mechanical assemblies were designed by Grundman, Roberts and Sebesta to accommodate the new optics, as well as providing interfaces to both CCD and IR cameras.

Crampton presented a paper at the Fourth CFHT User's Meeting in Lyon, arguing that wide-field imaging in the optical and near-infrared would be an important niche for CFHT in the future, and advocating that a new Cassegrain focus system be designed and built which incorporates fast tip/tilt and focus control.

Many staff members are deeply involved in a variety of work packages for the Gemini Telescopes project, of which the Gemini Adaptive Optics System (GAOS) and the Gemini Multiple Object Spectrograph (GMOS) are reported here. Herriot is the GAOS project manager, while Racine (U. de Montréal) and Walker (U. British Columbia) served as project scientists during the report year. The conceptual design previously developed for GAOS was based on the use of curvature wavefront sensing, which is the technology used in PUEO and also in the system being developed for the Subaru 8-m telescope. The review committee recommended that we adopt Shack-Hartmann wavefront sensing, which is used in many other systems. The issues surrounding this choice are quite complex. Unlike many telescopes, Gemini will have a fast tip-tilt-focus secondary mirror which can correct the lowest order atmospheric aberrations and wind

shake, over a wide field of view and with no penalties on throughput or emissivity. In addition, Gemini has an active optics system which will remove most low-order aberrations of the primary mirror. Thus GAOS would only be used when higher order correction is required, and when one is willing to accept the observational constraints of using it. As a result, the required order of correction is higher than had been assumed, and would require a Shack-Hartmann sensor to be achieved. A number of questions had been raised about the scientific necessity of GAOS so, at the urging of the International Gemini Project Office, an intensive, quantitative study of science drivers was undertaken by a DAO team led by Simon Morris. They evaluated the practical application of GAOS to a wide range of exciting scientific programs, and submitted a report to the Gemini Steering Committee in March 1996. In the meantime, Roberts worked on the conceptual designs, and Leckie provided manpower and cost estimates for the control system, and developed the frame rate and latency requirements based on the power spectral density of atmospheric turbulence.

GMOS is a collaboration between teams here and at Royal Observatory Edinburgh and the University of Durham. At DAO, the efforts are led by Murowinski (Project Manager), Crampton (Project Scientist) and Davidge. Morbey refined the optical design of the spectrograph, and made adjustments as necessary when glasses became unavailable and as specification parameters were tuned. Mechanical designs by Roberts (of the slit mask, mask handling system and wavefront sensor mechanics) and Szeto (structural analysis) have been incorporated. Saddlemeyer contributed design and documentation towards the GMOS project. Leckie produced cost and manpower estimates and a preliminary design for the GMOS control system. He co-authored a CCD controller survey report for the International Gemini Project Office, and co-authored a report entitled *SDSU-2 Detector Controllers* which identified how these controllers could be used to read-out CCDs employed on the Gemini instruments. Leckie is Canadian Project Manager for the Gemini WFS Work Package, a job that has entailed contract review, revision and coordination of the Canadian effort on this instrument. GMOS successfully passed its Preliminary Design Review in March 1996.

Wooff continues to develop the Enclosure Control System for Gemini, which successfully passed the system design review in June 1995.

Morbey continues to serve on the design and hardware team for the Lyman-FUSE satellite project, and is responsible for the optical design concepts of the fine error sensor of the pointing system. He remains as a design consultant for the light baffle system in the satellite, although the Canadian team is no longer responsible for that component.

Younger is adapting the design of a Richardson small off-axis spectrograph for application to a proposed automated spectrophotometric telescope, in collaboration with Adelman (The Citadel). The adaptation will allow simplified target acquisition, and includes a guide camera operating on the zero-order star image.

## 12. MISCELLANY

Starry Messenger Communications, in the persons of Don Moffatt and Fraser Chambers, worked under contract to conduct the Saturday evening programs from April through October, to provide daytime tours for school groups throughout the year, and to answer queries from the public. They gave some 180 tours. The total number of visitors attending the 1.8-m Plaskett dome during the year is estimated at 45 000. Younger operated the 41-cm telescope most Saturday evenings, while volunteers Sandy Barta, Rick McCrea, Keith Rawcliffe, Peter Schlatter and Steve Rayner provided steady support from the Victoria Centre of the Royal Astronomical Society of Canada (RASC) to the Saturday evening programs by setting up their own telescopes for visitors to use.

The Observatory hosts *ScienceWeb*, a science information service on the internet of particular interest to teachers and students. Scienceweb is available at <http://scienceweb.hia.nrc.ca> and is developed by Starry Messenger Communications under a grant from Industry Canada, a federal ministry. A spectacularly successful undertaking of *ScienceWeb* was a feature entitled 'The Great Canadian Hairy Star Party', which deseminated photos and information on C/1996 B2 Hyakutake. During the near-Earth passage of this comet in March 1996, more than 3 million connections were made to the comet webpage on ScienceWeb.

A graduate student 'Open House' and workshop on cosmology was held at the Observatory on November 17, 1995, organized Pat Côté and Ron Marzke, with contributions by many staff members.

Aikman hosted six 'dayshadow' work experience students at the Observatory, for durations of one to five days each.

Batten spent July to October, 1995, in the Department of Physics and Astronomy, University of Canterbury, New Zealand, as a Visiting Erskine Fellow. He gave two courses, one to first-year undergraduates and the other to a mixed group of senior undergraduates, graduate students and academic staff. He also gave seminars at the University and to a joint group in Wellington from the Carter Observatory and the Victoria University of Wellington. He lectured to the Canterbury Astronomical Society and visited Mt John Observatory and the Physics Department of the University of Otago, in Dunedin. After leaving New Zealand, he attended the National Seminar on Astrophysics and the Solar Eclipse in Ho Chi Minh City, Viet Nam, and visited the SUSI group at the University of Sydney, Australia. He is currently cooperating in the production of a survey of astronomy in developing countries to be published by the United Nations. Batten's paper on Eddington's thought on the relations between science and religion (QJRAS Vol. 35, 249-270, 1994) received an award from the Templeton Foundation.

Côté continued as a volunteer in the British Columbia 'Scientists in the Schools' outreach program, and he served as a scientific advisor for the Hydra/CTIO project.

Crampton continued to serve as a trustee of CASC-ATRUST, and as a member of the CTIO Time Assignment Committee.

Hesser serves on the CFHT Board of Directors, on the Council of the RASC Victoria Centre, the nominating committee of the Canadian Astronomical Society, as an Adjunct

Professor in the Department of Physics and Astronomy, University of Victoria, and on the Board of Editors of the Publications of the Astronomical Society of the Pacific. He co-chaired, with J. Liebert (U. Arizona), an American Astronomical Society committee charged with selecting a new Editor-in-Chief and Associate Editor for the *Astrophysical Journal*, and began service on an NSF review committee for NOAO. He gave Shapley Lectures at the University of Idaho in April. With Stetson and McClure, he co-supervises U. Victoria M.Sc. student M. Gim's research on the old open star cluster, NGC 7789. Hesser also continued to serve with the 'Scientist in the Schools' program.

Hutchings has worked on study teams for two NASA ultraviolet space projects, and has submitted a proposal for another project to CSA. He continues in the final science planning and characterisation of the HST STIS instrument, to be launched in early 1997. He also works as Canadian FUSE project scientist, with both the NASA and CSA parts now into construction phase. He begins terms on the CFHT Scientific Advisory Committee and Canadian Time Allocation Committee this year. He is assisting with the transfer of the HIA library to the DAO site, as library advisor.

McClure continued as the chairman of the DAO Time Assignment Committee. McClure gave a lecture to the Victoria Center of the Royal Astronomical Society of Canada, entitled "The Constellation Figures: When, Where, and Why?"

Simon Morris is chair of the CASCA Optical and IR Astronomy Committee, and a member of the Joint Committee for Space Astronomy. He taught Astronomy 511B 'Cosmology' at U. Victoria during autumn 1995; he is also adviser to graduate students Merleau and Balogh at U. Victoria.

Oke continues as Associate Editor for instrumentation of the Publications of the Astronomical Society of the Pacific. During the past year thirty-eight papers on instrumentation have been handled.

Smecker-Hane received an Annie Jump Cannon Special Commendation of Honor "in recognition of exceptional early research and professional accomplishments" from the American Association of University Women and the American Astronomical Society.

Stetson served on an HST time assignment panel and on a NASA panel on New Directions in Space Astronomy. He also co-supervised U. Victoria students M. Gim (MSc) and R. Zingle (PhD), and gave talks to the Victoria and Vancouver Centres of the Royal Astronomical Society of Canada.

Van den Bergh was awarded a D.Sc. (honoris causa) by St. Mary's University. He also received the Marlar Prize of Rice University. Van den Bergh ended his long service on the editorial board of *Vistas in Astronomy*, but continues to serve as a member of the board of the Canadian Institute for Theoretical Astrophysics.

### 13. PUBLICATIONS BY STAFF MEMBERS

Papers listed in this section and the section following are those bearing a 1995 cover date; a few papers inadvertently omitted from previous reports are also included.

Abraham, R.G., and van den Bergh, S., 1995. A Gauss-

Hermite expansion of the Galactic globular cluster luminosity function, *ApJ*, 438, 218-222.

- Adelman, S. J., Gulliver, A. F., Hill, G., and Pintado, O., 1995. Astrophysical gf values from high S/N data of A-type stars, in *Astrophysical Applications of Powerful New Atomic Databases*, eds. S.J. Adelman and W.L. Wiese, ASP Conference Series, 78, 455-466.
- Aikman, G.C.L., Balam, D.D., and Tatum, J.B., 1995. Observations of minor planets, *Minor Planet Circ.* 24461, 24634-5, 24816-7, 25582-4, 26046.
- Aikman, G.C.L., and Hesser, J.E., 1995. Dominion Astrophysical Observatory annual report for the period 1 April 1993 - 31 March 1994, *BAAS*, 27, 131-147.
- Balam, D.D., and Aikman, G.C.L., 1995. Observations of comets, *Minor Planet Circ.* 24423, 24598-24601.
- Baron, E., Hauschildt, P.H., Branch, D., Austin, S., Garnavich, P., Ann, H.B., Wagner, R.M., Filippenko, A.V., Matheson, T., and Liebert, J., 1995. Non-LTE spectral analysis and model constraints on SN 1993J, *ApJ*, 441, 170-181.
- Brandt, J.C., Heap, S.R., Beaver, E.A., Boggess, A., Carpenter, K.G., Ebbets, D.C., Hutchings, J.B., Jura, M., Leckrone, D.S., Linsky, J.L., Maran, S.P., Savage, B.D., Smith, A.M., Trafton, L.M., Walter, F.M., Weymann, R., Snow, M., Randall, C.E., Ake, T.B., Robinson, R.D., and Wahlgren, G., 1995. An atlas of  $\alpha$  Orionis obtained with the Goddard High Resolution Spectrograph on the Hubble Space Telescope, *AJ*, 109, 2706-2735.
- Brewer, J.P., Richer, H.B., and Crabtree, D.R., 1995. Late-type stars in M31. I. Photometric study of AGB stars and metallicity gradients, *AJ*, 109, 2480-2502.
- Brewer, J.P., Richer, H.B., and Crabtree, D.R., 1995. AGB populations in M31, in *Proceedings of the Fourth CFHT Users' Meeting*, ed. M. Azzopardi (Kamuela: CFHT Corporation), 63-79.
- Carlberg, R.G., Yee, H.K.C., Ellingson, E., Abraham, R., Gravel, P., Morris, S.L., Pritchet, C.J., Rigler, M.A., and Smecker-Hane, T.A., 1995. Cluster dynamics from the CNOC cluster survey, in *Proceedings of the Fourth CFHT Users' Meeting*, ed. M. Azzopardi (Kamuela: CFHT Corporation), 21-9.
- Côté, P., Fischer, P., Pryor, C., and Welch, D.L., 1995. Searching for spectroscopic binaries in M4 and M22, in *The Origins, Evolution and Destinies of Binary Stars in Clusters*, ASP Conference Series 90, eds. E.F. Milone and J.C. Mermilliod, 222-3.
- Côté, P., Welch, D.L., Fischer, P., and Gebhardt, K., 1995. Dynamics of the Galactic globular cluster NGC 3201, *ApJ*, 454, 788-806.
- Cowley, A.P., Schmidtke, P.C., Hutchings, J.B., Crampton, D., 1995. X-ray discovery of a hot PG1159 star, RX J0122.9-7521, *PASP*, 107, 927-930.
- Crampton, D., 1995. Imaging in the VLT and Gemini era, in *Proceedings of the Fourth CFHT Users' Meeting*, ed. M. Azzopardi (Kamuela: CFHT Corporation), 217-227.
- Crampton, D., Le Fèvre, O., Lilly, S.J., and Hammer, F., 1995. The Canada-France Redshift Survey V: global properties of the sample, *ApJ*, 455, 96-107.
- Crampton, D., Morbey, C.L., Le Fèvre, O., Hammer, F.,

- Tresse, L., Lilly, S.J., and Schade, D.J., 1995. Surveys for  $z > 1$  field galaxies, in Herstonceux Conference #35: 'Wide Field Spectroscopy and the Distant Universe', eds. S.J. Maddox and A. Aragon-Salamanca, (Singapore: World Scientific), 297-302.
- de Propis, R., Pritchett, C.J., Harris, W.E., and McClure, R.D., 1995. Evidence for steep luminosity functions in clusters of galaxies, *ApJ*, 450, 534-9.
- Dinshaw, N., Foltz, C.B., Impey, C.D., Weymann, R.J., and Morris, S.L., 1995. The large size of Lyman- $\alpha$  gas clouds at intermediate redshifts, *Nature*, 373, 223-5.
- Durand, D., Hill, N., Gaudet, S., and Crabtree, D., 1995. The CFHT archive system: building for the future upon past successes, in Proceedings of the Fourth CFHT Users' Meeting, ed. M. Azzopardi (Kamuela: CFHT Corporation), 267-275.
- Gebhardt, K., Pryor, C., Williams, T., and Hesser, J.E., 1995. Fabry-Perot observations of globular clusters. II. 47 Tuc, NGC 6397, and M 30, *AJ*, 110, 1699-1711.
- Hammer, F., Crampton, D., Le Fèvre, O., and Lilly, S.J., 1995. The Canada-France Redshift Survey IV: spectroscopic selection effects and 0300+00 field spectroscopic data, *ApJ*, 455, 88-95.
- Hammer, F., Crampton, D., Lilly, S.J., Le Fèvre, O., Kenet, T., and Tresse, L., 1995. The Canada-France Redshift Survey VII: optical counterparts of microJansky radio-sources, *MNRAS*, 276, 1085-1100.
- Hammer, F., Le Fèvre, O., Tresse, L., Lilly, S., and Crampton, D., 1995. Spectroscopic survey of 600 ultra-faint galaxies at CFHT, first results, *Astrophysical Letters and Communications*, 31, 49-54.
- Hammer, F., Lilly, S.J., Le Fèvre, O., Crampton, D., and Tresse, L., 1995. Deep spectroscopy of 780 galaxies: results and prospects for the VLT, in Science with the the VLT, eds. J.R. Walsh and I.J. Danziger, (Heidelberg: Springer-Verlag), 361-6.
- Harris, W.E., Pritchett, C.J., McClure, R.D., 1995. Globular cluster systems in three cD galaxies within rich Abell clusters, *ApJ*, 441, 120-8.
- Haser, S.M., Lennon, D.J., Kudritzki, R.P., Puls, J., Pauldrach, A.W.A., Bianchi, L., and Hutchings, J.B., 1995. The stellar wind of an O8.5 I(f) star in M31. A determination of mass loss rate and metallicity, *A&A*, 295, 136-146.
- Heap, S.R., Brandt, J.C., Randall, C.E., Carpenter, K.G., Leckrone, D.S., Maran, S.P., Smith, A.M., Beaver, E.A., Bogess, A., Ebbets, D.C., Garner, H.W., Hutchings, J.B., Jura, M., Linsky, J.L., Savage, B.D., Cardelli, J.A., Trafton, L.M., Walter, F.M., Weymann, R.J., Ake, T.B., Crenshaw, D.M., Malumuth, E.M., Robinson, R.D., Sandoval, J.L., Shore, S.N., Wahlgren, G.M., Bruhweiler, F., Lindler, D.J., Gilliland, R.L., Hulbert, S.J., Soderblom, D.R., 1995. The Goddard High-Resolution Spectrograph: In-orbit performance, *PASP*, 107, 871-887.
- Hesser, J.E., 1995. The Galactic globular cluster system, in Stellar Populations, IAU Symposium 164, eds. P.C. van der Kruit and G. Gilmore, (Dordrecht: Kluwer), 51-65.
- Hill, G., 1995. Spectroscopic reduction and analysis programs at the DAO, in ADASS IV, eds. R.A. Shaw H.E. Payne and J.J.E. Hayes, ASP Conference Series, 77, 443-452.
- Hill, G., and Holmgren, D., 1995. Studies of early-type variable stars. IX. Y Cygni, *A&A*, 297, 127-134.
- Holmgren, D., Hill, G., and Scarfe, C.D., 1995. New apsidal-motion parameters for Y Cygni, *Observatory*, 115, 188-192.
- Hutchings, J.B., 1995. Galaxy companions to QSOs at  $z=2.3$ , *AJ*, 109, 928-934.
- Hutchings, J.B., 1995. QSO Host Galaxies at  $z=2.3$ , *AJ*, 110, 994-7.
- Hutchings, J.B., Abraham, R., Smecker-Hane, T., Morris, S.L., Davidge, T., Rigler, M., Carlberg, R., Yee, H., and Ellingson, E., 1995. Populations in the  $z=0.23$  rich cluster Abell 2390, in Stellar Populations, IAU Symposium 164, eds. P.C. van der Kruit and G. Gilmore, (Dordrecht: Kluwer), 463-3.
- Hutchings, J.B., Cowley, A.P., Schmidtke, P.C., and Cramp-ton, D., 1995. UV spectra of the eclipsing LMC X-ray binary CAL 87, *AJ*, 110, 2394-9.
- Hutchings, J.B., Crampton, D., Cowley, A.P., Schmidtke, P.C., McGrath, T.K., and Chu, Y., 1995. An X-ray selected white dwarf + M dwarf binary: RX J0458.9-6628, *PASP*, 107, 931-6.
- Hutchings, J.B., Crampton, D., and Johnson, A., 1995. Companions of QSOs at redshift 1.1, *AJ*, 109, 73-80 and 456.
- Hutchings, J.B., and Morris, S.C., 1995. Imaging of low redshift QSOs with WFPC2, *AJ*, 109, 1541-5.
- Jones, L.R., McHardy, I.M., Merrifield, M., Branduardi-Raymont, G., Mason, K.O., Smith, P.J., Abraham, R., Dalton, G., Wegner, G., Rowan-Robinson, M., Luppino, G.A., and Lehto, H.J., 1995. in Herstonceux Conference #35: 'Wide Field Spectroscopy and the Distant Universe', eds. S.J. Maddox and A. Aragon-Salamanca, (Singapore: World Scientific), 339-346.
- Korista, K.T., *et al.* (111 authors including S.L. Morris), 1995. Steps toward determination of the size and structure of the broad-line region in active galactic nuclei. VIII. An intensive HST, IUE, and ground-based study of NGC 5548, *ApJS*, 97, 285-330.
- Lahav, O., Naim, A., Buta, R.J., Corwin, H.G., de Vaucouleurs, G., Dressler, A., Huchra, J.P., van den Bergh, S., Raychaudhury, S., Sodre Jr., L., and Storrie-Lombardi, M.C., 1995. Galaxies, human eyes and artificial neural networks, *Science*, 267, 859-862.
- Lai, O., ... Crampton, D., *et al.* 1995. CFHT adaptive optics integration and characterization, in Adaptive Optics, ESO Conference Series #54, ed. M. Cullum, 491-6.
- Le Fèvre, O., Crampton, D., Hammer, F., Lilly, S.J., and Tresse, L., 1995. Deep redshift surveys on faint galaxies: results and prospects for the VLT above  $z=1$ , in Science with the the VLT, eds. J.R. Walsh and I.J. Danziger, (Heidelberg: Springer-Verlag), 367-371.
- Le Fèvre, O., Crampton, D., Lilly, S.J., Hammer, F., and Tresse, L., 1995. The Canada-France Redshift Survey II: spectroscopic program; data for the 0000-00 and 1000+25 fields, *ApJ*, 455, 60-74.
- Lilly, S.J., Hammer, F., Le Fèvre O., and Crampton, D., 1995. The Canada-France Redshift Survey III: "single

- emission line'' objects, analysis of repeat observations and spectroscopic identifications in the 1415+52 and 2215+00 fields, *ApJ*, 455, 75-87.
- Lilly, S.J., Le Fèvre, O., Crampton, D., Hammer, F., Tresse, L., Schade, D., and Hudon, D., 1995. The Canada-France Redshift Survey and the Universe at half the Hubble time, in *Proceedings of the Fourth CFHT Users' Meeting*, ed. M. Azzopardi (Kamuela: CFHT Corporation), 11-9.
- Lilly, S.J., Le Fèvre, O., Crampton, D., Hammer, F., and Tresse, L., 1995. The Canada-France Redshift Survey I: introduction to the survey, photometric catalogues and surface brightness selection effects, *ApJ*, 455, 50-59.
- Lilly, S.J., Le Fèvre, O., Hammer, F., Crampton, D., and Tresse, L., 1995. The Canada-France Redshift Survey and the evolution of the galaxy luminosity function to high redshift, in *Herstmonceux Conference #35: 'Wide Field Spectroscopy and the Distant Universe'*, eds. S.J. Maddox and A. Aragon-Salamanca, (Singapore: World Scientific), 281-9.
- Lilly, S.J., Tresse, L., Hammer, F., Crampton, D., and Le Fèvre, O., 1995. The Canada-France Redshift Survey VI: evolution of the galaxy luminosity function to  $z \sim 1$  and beyond, *ApJ*, 455, 108-124.
- Marzke, R.O., Geller, M.J., da Costa, L.N., and Huchra, J.P., 1995. Pairwise velocities of galaxies in the CfA and SSRS2 redshift surveys, *AJ*, 110, 477-501.
- Maxted, P., Hill, G., and Hilditch, R.W., 1995. Studies of early-type variable stars. XIII. Spectroscopic orbit and absolute parameters of TX Ursae Majoris, *A&A*, 301, 135-140.
- Maxted, P., Hill, G., and Hilditch, R.W., 1995. Studies of early-type variable stars. XIV. Spectroscopic orbit and absolute parameters of HU Tauri, *A&A*, 301, 141-8.
- McClure, R.D., 1995. Observations of Cepheids in Virgo from CFHT, in *Proceedings of the Fourth CFHT Users' Meeting*, ed. M. Azzopardi (Kamuela: CFHT Corporation), 55-61.
- McHardy, I.M., Merrifield, M.R., Abraham, R.G., and Crawford, C.S., 1994. HST observations of the BL Lac object PKS 1413+135: the host galaxy revealed, *MNRAS*, 268, 681-9.
- Miville-Deschenes, M., Joncas, G., and Durand, D., 1995. The H II region Sharpless 170: A multiscale analysis of the H $\alpha$  velocity field, *ApJ*, 454, 316-326.
- Morris, S.L., 1995. Lyman- $\alpha$  absorption and tidal debris, in *Herstmonceux Conference #35: 'Wide Field Spectroscopy and the Distant Universe'*, eds. S.J. Maddox and A. Aragon-Salamanca, (Singapore: World Scientific), 362-7.
- Mould, J., Huchra, J.P., Bresolin, F., Ferrarese, L., Ford, H.C., Freedman, W.L., Graham, J., Harding, P., Hill, R., Hoessel, J.G., Hughes, S.M., Illingworth, G.D., Kelson, D., Kennicutt Jr., R.C.J., Madore, B.F., Phelps, R., Stetson, P.B., and Turner, A., 1995. Limits on the Hubble constant from the HST distance of M100, *ApJ*, 449, 413-421.
- Naim, A., Lahav, O., Buta, R.J., Corwin, H.G., Jr., de Vaucouleurs, G., Dressler, A., Huchra, J.P., van den Bergh, S., Raychaudhury, S., Sodre, L., Jr., Storrie-Lombardi, M.C., 1995. A comparative study of morphological classifications of APM galaxies, *Monthly Notices of the Royal Astronomical Society*, 274, 1107-1125.
- Neff, S.G., Roberts, L., and Hutchings, J.B., 1995. VLA maps of radio galaxies to  $z=1$ , *ApJS*, 99, 349-389.
- Pierce, M.J., Welch, D.L., McClure, R.D., van den Bergh, S., Racine, R., and Stetson, P.B., 1995. The Hubble constant from Cepheid variables in the Virgo Cluster, *CFHT Information Bulletin* 32, 19-21.
- Pryor, C., Williams, T., Gebhardt, and Hesser, J.E., 1995. The kinematics of globular clusters from SIS Fabry-Perot observations, *CFHT Bulletin* 32, 16-8.
- Richer, H.B., Fahlman, G.G., Ibata, R.A., Stetson, P.B., Bell, R.A., Bolte, M., Bond, H.E., Harris, W.E., Hesser, J.E., Mandushev, G., Pryor, C., and Vandenberg, D.A., 1995. Hubble Space Telescope observations of white dwarfs in the globular cluster M4, *ApJL*, 451, L17-L20.
- Schade, D.J., Lilly, S.J., Crampton, D., Hammer, F., Le Fèvre, O., and Tresse, L., 1995. The Canada-France Redshift Survey IX: HST imaging of high redshift field galaxies, *ApJL*, 451, L1-4.
- Shafter, A.W., Robinson, E.L., Crampton, D., Warner, G., Prestage, R., 1995. V795 Herculis (PG 1711+336) A new intermediate polar in the period gap: Erratum, *ApJ*, 438, 1017-7.
- Smith, G.H., Woodsworth, A.W., and Hesser, J.E., 1995. A search for CO(2-1) emission from the globular cluster M15, *MNRAS*, 273, 632-8.
- Stetson, P.B., 1995. Globular clusters observed with the CFHT, in *Proceedings of the Fourth CFHT Users' Meeting*, ed. M. Azzopardi (Kamuela: CFHT Corporation), 81-7.
- Valdes, F., Campusano, L.E., Velaquez, J.D., and Stetson, P.B., 1995. FOCAS automatic catalog matching algorithms, *PASP*, 107, 1119-1128.
- van den Bergh, S., 1995. The age and size of the Universe, *JRASC*, 89, 6-10.
- van den Bergh, S., 1995. Questions of clusters, *Nature*, 374, 215-6.
- van den Bergh, S., 1995. A preliminary classification scheme for the central regions of late-type galaxies, *AJ*, 110, 613-9.
- van den Bergh, S., 1995. Perigalactic distances of globular clusters, *AJ*, 110, 1171-6.
- van den Bergh, S., 1995. On the discrepancy between the Cepheid and RR Lyrae distance scales, *ApJ*, 446, 39-43.
- van den Bergh, S., 1995. Supernovae, globular clusters, and galaxy mergers, *ApJ*, 450, 27-31.
- van den Bergh, S., 1995. Are the luminosities of RR Lyrae stars affected by second parameter effects? *ApJL*, 451, L65-6.
- van den Bergh, S., 1995. A new method for the determination of the Hubble parameter, *ApJL*, 453, L55-6.
- van den Bergh, S., 1995. Better parallaxes and the cosmic distance scale, in *Astronomical and Astrophysical Objectives of Sub-milliarcsecond Optical Astrometry*, IAU Symposium 166, eds. E. Hoeg and K. Seidelman, (Dordrecht: Kluwer), 267-272.
- West, M.J., Côté, P., Jones, C., Forman, W., and Marzke, R., 1995. Intracluster globular clusters, *ApJL*, 453, L77-L80.

- Weymann, R.J., Rauche, M., Williams, R., Morris, S.L., and Heap, S., 1995. New observations with the HST GHRS of the low redshift Lyman- $\alpha$  clouds in the 3C273 line of sight, *ApJ*, 438, 650-658.
- Yee, H.K.C., Ellingson, E., Carlberg, R.G., Gravel, P., Abraham, R., Morris, S.L., Rigler, M., and Smecker-Hane, T., 1995. in *Herstmonceux Conference #35: 'Wide Field Spectroscopy and the Distant Universe'*, eds. S.J. Maddox and A. Aragon-Salamanca, (Singapore: World Scientific), 233-8.
- #### 14. PUBLICATIONS BY VISITORS
- Adelman, S.J., and Philip, A.G.D., 1995. Elemental abundances of sharp-lined population I main sequence B, A, and F stars and population II A stars, in *Stellar Populations*, IAU Symposium 164, eds. P.C. van der Kruit and G. Gilmore, (Dordrecht: Kluwer), 359-9.
- Adelman, S. J., Pyper, D.M, Lopez-Garcia, Z., and Caliskan, H., 1995. On the effective temperatures, surface gravities, and optical region fluxes of the magnetic CP Stars, *A&A*, 296, 467-472.
- Balam, D.D., 1995. Observations of minor planets, *Minor Planet Circ.* 24971, 25123-4, 25272-3, 25378-9, 25696, 25800.
- Balam, D.D., 1995. Observations of comets, *Minor Planet Circ.* 24782, 25247, 25753, 25996-8.
- Balam, D.D., 1995. Astrometry of Comet P/1995 A1 (Jedicke), *IAU Circular* 6127.
- Balam, D.D., 1995. Supernova 1995E in NGC 2441, *IAU Circular* 6138.
- Balam, D.D., 1995. Supernova 1995V in NGC 1087, *IAU Circular* 6203.
- Batten, A.H., 1995. International cooperation in astronomy: the role of the International Astronomical Union, *AIP Conference Proceedings* 320, 3-5.
- Batten, A.H., 1995. Stellar evolution in binary systems, *Reports on Progress in Physics* 58, 885-928.
- Batten, A.H., 1995. Some aspects of binary stars, *AIP Conference Proceedings* 320, 193-5.
- Caliskan, H., 1995. Normal ve ozel a yildizlarinin spektrum sentez teknigi ile atmosfer yapilarinin incelenmesi, *Doktoral thesis (in Turkish)*, Istanbul University.
- Caliskan, H., and Adelman, S. J. 1995. Elemental abundances of the magnetic chemically peculiar star HD 204411, in *Astrophysical Applications of Powerful New Atomic Databases*, eds. S.J. Adelman and W.L. Wiese, *ASP Conference Series*, 78, 443-450.
- Carquillat, J., Griffin, R., and Ginestet, N., 1995. Contribution a l'etude des spectres composites. VII. HD 16646, *AP&SSS*, 110, 173-6.
- Downes, R., Hoard, D.W., Szkody, P., and Wachter, S., 1995. Spectroscopy of poorly studied cataclysmic variables, *AJ*, 110, 1824-1837.
- Favata, F., Barbera, M., Micela, G., and Sciortino, S., 1995. Lithium, X-ray activity and rotation in an X-ray selected sample of solar-type stars, *A&A*, 295, 147-160.
- Fieldus, M.S., and Bolton, C.T., 1994. A survey of line profile variations in non-emission line B0-B5 II-V stars, in *Pulsation, Rotation and Mass-Loss in Early-Type Stars*, IAU Symposium 162, eds. L.A. Balona, H.F. Henrichs and J.M. le Contel, (Dordrecht: Kluwer), 108-9.
- Griffin, R.F., 1995. An improved orbit for the double-lined Pleiades binary HD 23642, *JRASC*, 89, 53-61.
- Griffin, R.F., 1995. Spectroscopic binary orbits from photoelectric radial velocities. Paper 121: 61 Ceti, *Observatory*, 115, 84-90.
- Griffin, R.F., 1995. Spectroscopic binary orbits from photoelectric radial velocities. Paper 123: 17 Hydrae A, *Observatory*, 115, 193-202.
- Hill, G.M., 1995. Compositional differences among the A-type stars. II. Spectrum synthesis up to  $v \sin i = 110$  km/s, *A&A*, 294, 536-546.
- Hill, G.M., and Underhill, A.B., 1995. WR+O binaries observed from the DAO, in *Wolf-Rayet Stars: Binaries, Colliding Winds, Evolution*, IAU Symposium #163, eds. K.A. van der Hucht and P.M. Williams, (Dordrecht: Kluwer) 235-8.
- Hrivnak, B.J., 1995. Optical spectroscopy of carbon-rich proto-planetary nebulae, *ApJ*, 438, 341-9.
- Kambe, E., 1994. Growth of the line-profile variation region during Be episodes, in *Pulsation, Rotation and Mass-Loss in Early-Type Stars*, IAU Symposium 162, eds. L.A. Balona, H.F. Henrichs and J.M. le Contel, (Dordrecht: Kluwer), 368-9.
- Marchenko, S.V., Moffat, A.F.J., Eenens, P.R.J., Hill, G.M., and Grandchamps, A., 1995. Wind-wind interaction in the close Wolf-Rayet binary CQ Cephei (WN6+O9II-Ib), *ApJ*, 450, 811-823.
- Matthews, J.M., Gieren, W.P., Mermilliod, J.C., and Welch, D.L., 1995. Independent distance determinations to Milky Way Cepheids in open clusters and associations. II. CF Cas in NGC 7790, *AJ*, 110, 2280-7.
- McAlister, H.A., Hartkopf, W.I., Mason, B.D., Fekel, F.C., Ianna, P.A., and Tokovinin, A.A., 1995. Binary star orbits from speckle interferometry. VI. The nearby solar-type speckle-spectroscopic binary HR 6697, *AJ*, 110, 366-375.
- Micela, G., Favata, F., Pye, J., and Sciortino, S., 1995. The discovery of a very active high proper motion dMe binary star, *A&A*, 298, 505-516.
- Milone, E.F., Stagg, C.R., Sugars, B.A., McVean, J.R., Schiller, S.J., Kallrath, J., and Bradstreet, D.H., 1995. Observations and analysis of the contact binary H235 in the open cluster NGC 752, *AJ*, 109, 359-377.
- Nelson, R.H., Milone, E.F., VanLeeuwen, J., Terrell, D., Penfold, J.E., and Kallrath, J., 1995. Observations and analysis of the field contact binary V728 Herculis, *AJ*, 110, 2400-7.
- Nemec, J.M., Mateo, M., Burke, M., and Olszewski, E.W., 1995. SX Phoenixis stars in the extremely metal-poor globular cluster NGC 5053, *AJ*, 110, 1186-1228.
- Nemec, J.M., Matteo, M., and Schombert, J.M., 1995. B,V photometry of the RR Lyrae stars in the very metal-poor globular cluster NGC 5053, *AJ*, 109, 618-630.
- Oke, J.B., Cohen, J.G., Carr, M., Cromer, J., Dingizian, A., Harris, F.H., Labrecque, S., Lucinio, R., Schaal, W., Epps, H., and Miller, J., 1995. The Keck Low-Resolution Imaging Spectrometer, *PASP*, 107, 375-385.
- Reid, A.H., Bolton, C.T., Crowe, R.A., Fieldus, M.S., Ful-

- lerton, A.W., Gies, D.R., Howarth, I.D., McDavid, D., Prinja, R.K., and Smith, K.C., 1993. Time-series observations of O stars. II. Optical observations of  $\zeta$  Ophiuchi, *ApJ*, 417, 320-337.
- Rosvick, J.M., and Davidge, T.J., 1995. An infrared embedded source in the L1251 molecular cloud, *PASP*, 107, 49-57.
- Schmidt, E.G., Chab, J.R., and Reiswig, D.E., 1995 The Behlen Observatory variable star survey. Paper III, *AJ*, 109, 1239-1262.
- Soifer, B.T., Cohen, J.G., Armus, L., Matthews, K., Neugebauer, G., and Oke, J.B., 1995. Near-infrared and optical spectroscopy of FSC 10214 +4724, *ApJL*, 443, L65-8.
- Tarasov, A., Harmanec, P., Horn, J., Lyubimkov, L., Rostopchin, S., Koubsky, P., Blake, C., Kostunin, V., Walker, G., and Yang, S., 1995. The archetype line-profile variable epsilon 45 Persei is a spectroscopic triple system, *AP&SSS*, 110, 59-79.
- Underhill, A.B., 1995. A study of the spectra of seven Of stars. I. Radial velocities, *ApJS*, 420, 433-460.
- Underhill, A.B., 1995. A study of the spectra of seven Of stars. II. Line profiles and equivalent widths, *ApJS*, 420, 461-471.
- Underhill, A.B., and Matthews, J.M., 1995. A spectroscopic orbit for the O8If star 9 Sge, *PASP*, 107, 513-6.
- Walker, G.A.H., Walker, A.R., Irwin, A.W., Larson, A.M., Yang, S.L.S., and Richardson, D.C., 1995. A search for Jupiter mass companions to nearby stars, *Icarus* 116, 359-375.

G.C.L. Aikman  
James E. Hesser, Director