

Applied Research Corporation
Landover, Maryland 20785

URL: <http://www.arcorp.com/> This report covers the period 30 September 1994 to 1 October 1995

1. INTRODUCTION

Applied Research Corporation (ARC) is a for-profit corporation founded in 1979 by Dr. S.P.S. Anand. ARC scientists fulfill a variety of rolls including; technical support and management of large projects, assistance of government scientists with customized, individual science support, and pursuit of their own scientific programs. In order to maintain the highest possible level of scientific proficiency, ARC encourages its scientists to pursue their own research interests and it supports them in establishing active research careers. ARC currently supports two large, ongoing projects of astronomical significance. These are the Cosmic Background Explorer (*COBE*) and the Solar and Heliospheric Observatory (*SOHO*), scheduled to be launched at the end of this year. As of October 1995, ARC staff scientists with astronomy related interests are: B. Altner, S.P.S. Anand, R. Arendt, K. Black, J.H. Clark, H.H. Davé, A.S. Endal, D. Fixsen, B. Franz, J.M. Gales, R. Ghosh, W.J. Glaccum, C. Grady, T. Kucera, D.G. Luttermoser, D.L. Massa, J.G. Mengel, T. Moran, J. Newmark, N. Nitta, P. Noerdlinger, S. Odenwald, M. Pérez, W.D. Pesnell, E. Siregar, T. Sodroski, S.W. Stemwedel, W.T. Thompson, L.W. Twigg, W.L. Waldron, L. Wang, H.A. Weaver, D.A. Wynne, D.M. Zarro, and I. Zayer.

2. RESEARCH PROGRAMS

2.1 Cosmology and ExtraGalactic Astronomy

Arendt continued working with DIRBE data obtained by the *COBE* satellite. He contributed to the effort of extracting the cosmic infrared background radiation (CIBR) from the DIRBE data. Arendt adapted models for removing the foreground emission from stars within our own Galaxy, and devised methods for removing the foreground emission of the interstellar medium. After these foregrounds, and that of the zodiacal emission [model by Franz (ARC) and others], are removed from the DIRBE data, Arendt has been involved in the assessment of the strength and isotropy of any residual extragalactic signal.

Fixsen remains involved with the *COBE* FIRAS data. He has helped uncovered flaws in the previous calibration and has lead the effort in formulating a new calibration. When completed, this calibration will make significant improvements in the noise and systematics, improving the accuracy of the cosmological results from the FIRAS.

Fixsen participated in another flight of the Medium Scale Anisotropy Measurement (MSAM) balloon payload at Palestine TX. This flight collected roughly 5 hrs of high latitude data. Another flight is planned for next 1996 May/June with a new detector. The new detector is more sensitive and will cover a larger portion of sky. The previous detector observed at 4 bands, 5.6, 9.0, 16.5, and 22.5 cm^{-1} . The new detector

has 5 bands from 2–6 cm^{-1} . In both cases the goal is to study anisotropy on angular scales of $\sim 0.5^\circ$.

Fixsen has also been involved with ARCADE, which will measure the absolute CMBR at 3 frequencies from 10-40 GHz. The measurement will use an open dewar with a cold (2.7K) calibrator to compare to the sky. The calibrator will cover the aperture of the horn. The residual atmospheric radiation will be estimated by tipping the dewar. With no window and only the atmosphere above 130,000 ft, an absolute measurement with sub mK errors may be possible. There are several theoretical distortions of the CMBR which have a maximum deviation in the antenna temperature at these frequencies.

Odenwald is currently involved with IR photometry of M31 from 1 - 240 microns using DIRBE. In collaboration with Newmark (ARC) and Smoot (NASA/GSFC), Odenwald is also examining the detectability of the intermediate extragalactic foreground contributed by IRAS-detected galaxies, and they recently completed a paper describing the *COBE*/DIRBE detection of 54 galaxies.

Odenwald is also collaborating with Mather and Kashlinsky(NASA/GSFC) on the investigation of the cosmic infrared background based on a study of sky intensity fluctuations. This effort was awarded a NASA Long Term Astrophysics grant for 5 years.

Pérez, Danks and Fanelli (Hughes STX/GSFC) have continued their analysis of the optical (spectroscopy and imaging) and *IUE* data of the gas-rich S0 galaxy, NGC 7233. The preliminary population synthesis, determined primarily by the weighted contribution per spectral type of selected UV features, indicates that this galaxy contains a large number of giant stars and abnormally blue objects. The environment of NGC 7233 appears to be disturbed by the presence of the nearby, and potentially interacting galaxy, NGC 7232, which could explain the difference in stellar populations derived upon slight changes in the positions of the *IUE* aperture.

2.2 Interstellar Medium and Galactic Structure

Arendt, in collaboration with E. Dwek, H. Moseley, and G. Sonneborn (NASA), has been awarded time on the European Infrared Space Observatory (*ISO*) satellite for observations of the Cas A supernova remnant using the Short Wavelength Spectrograph (SWS). This work is motivated by, and will improve upon, the *KAO* observations of Cas A obtained by Moseley *et al.* which detected a strong 26 micron line, and a strong continuum which contains unique broad features, apparently from unusual silicate dust grains. The *ISO* observations will help to determine whether the 26 micron line is from oxygen or iron, and to identify the nature of silicate dust which produces the continuum features.

Under a separate, successful proposal, Dwek (NASA) and Arendt will obtain *ISO* ISOPHOT photometer observations in order to search for evidence of dust destruction within supernova remnants. Observations will dissect the shock

front of either the Puppis A or RCW 86 remnants, tracing the variation in the IR emission of small dust grains which are likely to be destroyed during their passage into the shock.

Arendt has also been working with E. Dwek to develop a model of the near-IR emission of the Galaxy, that incorporates the extinction of individual dust clouds whose locations have been determined by an analysis of CO and H I data by Sodroski (ARC) and N. Odegard (GSC). By matching the model to the DIRBE observations, the model will be used to resolve the distance ambiguity of clouds in the inner Galaxy, and to draw a consistent picture of both the far-IR emission and near-IR extinction of the Galactic dust. This work is funded by an Astrophysics Data Program (ADP) grant.

Odenwald was involved in Galactic center research lead by Sodroski (ARC) which resulted in a publication (Sodroski *et al.* 1995). He was also involved with Orion nebular research (Wall *et al.* 1995).

Massa was awarded an ADP grant to pursue kinematic modeling of Galactic halo gas. This is a continuation of previous work to characterize the global motion and structure of highly ionized gas in the Galactic halo. The work consists of developing a parameterized model for the motion and density of the halo gas and then performing non-linear least squares fits to a set of interstellar line profiles by varying the model parameters.

2.3 Cometary Physics

Weaver (who joined ARC this year as Director of Planetary Systems Research) has mainly been involved in the continuing investigations of comet Shoemaker-Levy 9 (SL9) and its impact into Jupiter. He served as the Chair of the Science Observation Team which designed and implemented the successful SL9-Jupiter observing campaign using the Hubble Space Telescope (*HST*). He led the comet investigation team and was a co-I on several of the Jovian investigations. The preliminary results from these programs were summarized in a series of papers published in a single issue of *Science* in March 1995. More detailed work is in progress. Weaver also helped to organize an international meeting on the SL9-Jupiter impacts during the spring of 1995 and is serving as one of the editors of a book being published by Cambridge University Press which will contain the review papers presented at the meeting.

As this report goes to press, Weaver has just begun an *HST* investigation of comet C/1995 O1 (Hale-Bopp), which will probably be the brightest comet of the past two decades. Results on cometary astronomy are continually updated, and are accessible through the ARC home page on the World Wide Web (WWW) or directly via: <http://www.arcorp.com/Hale-Bopp.html>

2.4 Star Formation and Protoplanetary Evolution

As part of her NASA Long-Term Space Astrophysics study award, Grady has been involved in an extensive multi-wavelength study of the circumstellar material surrounding pre-main sequence and main sequence intermediate-mass stars. Grady and Pérez (ARC) with Talavera (LAEFF/INTA), Bjorkman (Wisconsin), Thé, de Winter, Molster, and van den

Ancker (Amsterdam), Sitko (Cincinnati), Morrison and Beaver (Toledo), McCollum (CSC) and Castelaz (E. Tenn. State) have completed a survey of UV and optical high dispersion spectra of Herbig Ae/Be and related stars. Accreting, circumstellar gas is present in UV line profiles over the velocity range $+100$ to $+400$ km s⁻¹ in 33% of 39 H AeBe stars and in 4 non-emission line B stars. An additional 10, fainter, H AeBe stars show accretion signatures in optical spectra. As a group, these objects have structure in the accreting gas line profiles similar to that seen in β Pic, although with significantly higher column densities. As a group, these stars tend to exhibit large amplitude optical light variations. All of the program stars with polarimetric variability which is anti-correlated with the light level show spectral signatures of accreting gas. These data imply that accretion is preferentially observed in these stars when the line of sight transits the circumstellar dust disk. Our data imply that the spectroscopic signatures of accreting circumstellar gas are not unique to β Pic, but instead are consistent with interpretation of β Pic as a comparatively young *star+disk* system.

Grady and Pérez with Talavera (LAEFF/INTA) examined archival *IUE* spectra of field A stars with optically-identified shell spectra and found accreting gas visible to $+100$ km s⁻¹ in 9 stars, including the previously identified β Pictoris and HR 10. Subsequently, in collaboration with McCollum, England, Rawley, Grobner, and Schlegl (CSC), an additional 3 stars have been observed, bringing the total sample to 18 stars, 15 of which showed UV signatures of the presence of circumstellar gas at the epoch of the *IUE* observations. Eleven of the program stars, or 61% of the sample, showed higher velocity, accreting, circumstellar gas similar to that seen toward beta Pictoris, but lower in column density. Given the documented variability in the strength of circumstellar shell features in A stars, this detection rate most probably represents a lower bound to the true frequency of accretion toward these stars. With the exception of β Pic, these A shell stars have IR excesses resembling Vega, suggesting that the central portions of the circumstellar dust disks are more centrally cleared. Together with our work on Herbig Ae/Be stars, the pre-main sequence (PMS) precursors of stars like β Pic, these data suggest that the uniqueness of β Pic is likely tied to the disk being in a comparatively short-lived evolutionary phase.

Grady, with England, Rawley, McCollum, Grobner, and Schlegl (CSC) have obtained *IUE* high dispersion spectra of the λ Boo star, 131 Tau (A2 Va+) which show accreting, circumstellar gas visible to $+80$ km s⁻¹ relative to the star. Overall the mid and far-UV spectra of this star closely resemble field A shell stars such as HR 10 rather than more extreme λ Boo stars. Together with recent studies on the metallicity of β Pic, these data imply that circumstellar accretion occurs independently of the metallicity of the star.

Grady and Pérez with Bjorkman (Wisconsin) obtained *IUE* high dispersion spectra of the Herbig Ae star, HD 163296, at the time of WUPPE UV spectropolarimetric observations during the Astro-2 mission. Previous observations of this star had indicated the presence of periodically modulated outflowing gas. The recent *IUE* data show a compara-

tively low state of outflowing material together with the unexpected detection of accreting gas with velocities as high as $+150 \text{ km s}^{-1}$. The accreting gas is collisionally ionized, as demonstrated by the presence of C iv in the accreting material but not in the outflowing gas. Inspection of the available archival *IUE* spectra indicates that accretion was present in earlier spectra, but at a lower level than seen in the *IUE* data. The WUPPE spectropolarimetry indicate the presence of a polarization position angle reversal similar to that seen during Astro-1 in HD 45677, which suggests that HD 163296 is viewed closer to the disk plane than had previously been thought.

2.5 Stellar Physics

Luttermoser has been working on two projects during this past year. Details of the work done for the *SOHO* contract are described elsewhere in this report. The second project involves NLTE radiative transfer modeling of semiregular variable star atmospheres through a NASA ADP award. This research grant, entitled "The Chromosphere/Shock Dilemma of Non-Mira, Late-Type Variable Stars," was awarded for a three year duration beginning September 1995 with Luttermoser as PI and L.A. Willson and G. Bowen (Iowa State U.) as co-I's. In the past, Luttermoser has collaborated with Bowen and Willson in carrying out NLTE synthetic spectrum calculations of the Bowen hydrodynamic models of Mira-type variables, in particular, models representing R Leo (M6-M8 IIIe) and S Car (K5-M4 IIIe) (Luttermoser, Bowen, and Willson 1996). Also, Luttermoser has generated hydrostatic chromospheric models of two non-Mira cool giant stars, TX Psc (N0 II) and g Her (M6 III). Both of these stars are semiregular variables. However, these hydrostatic models could not be constrained to reproduce both the Mg ii h and k emission line profiles and the C ii] (UV0.01) intersystem line ratios, as observed with *IUE*, under the assumptions made on the models. Surprisingly, both the optically thin C ii] lines, whose line ratios are sensitive to the electron density, and the peak flux of the Mg ii lines originate from the same region of the chromosphere in the 1-D, hydrostatic models. One of the main conclusions made in Luttermoser, Johnson, & Eaton (1994) for the g Her chromospheric model was that the structure of the chromospheric emitting layers are dominated by hydrodynamic and not hydrostatic processes in the cool semiregular variable stars.

Continued work on the NASA/ADP grant consists of Bowen generating hydrodynamic models representative of two semiregular variables, g Her and R Lyr (M5 III) and then Luttermoser calculating NLTE synthetic spectra of these models with the PANDORA program. The results are then compared to observed *IUE* spectra to see whether the hydrodynamic models can reproduce the observations. If so, this will be an important finding since all modeling to date of these type of stars assumes a 1-D, hydrostatic and chemical equilibrium atmosphere. The initial progress of this research has been reported in Luttermoser (1996, 1996).

Luttermoser has also been carrying out additional research on in collaboration with H. Johnson (Indiana U.). Luttermoser is a co-I on a large *HST* grant to investigate the UV

emission and chromospheric structure of cool red giant stars. The initial results of this work can be found in Johnson *et al.* (1995).

Massa was the PI on an *HST* GO program with Nancy Evans (CfA), Ken Carpenter (GSFC) and Rich Robinson (CSC) to determine the spectroscopic orbit of the B star component of the classical Cepheid Binary T Mon. When combined with model atmosphere analysis of the B star, this will provide a measure of the distance, mass and absolute luminosity of the Cepheid primary. Observations for this program have just been completed.

Massa was the PI on a massive *IUE* observing campaign which involved 33 co-investigators from the US, Canada, Mexico and Europe. The observations consisted of 16 continuous days in January 1995, during which 444 high dispersion spectra were obtained of three early-type stars: 1) the Wolf-Rayet star HD 50896, 2) the O supergiant ζ Puppis, and 3) the B supergiant HD 64760. These observations were used to follow the development and evolution of inhomogeneities in the stellar winds of the program stars and to determine whether these repeat from one rotation cycle to the next. The results of the program were an outstanding success, and have already been published in 4 *ApJ Letters* (Massa *et al.* 1995, Moffat *et al.* 1995, Prinja *et al.* 1995, and Holwarth *et al.* 1995) and can also be viewed on the project's WWW Home Page (accessible through the ARC Home Page) which was constructed and updated throughout the observing run, as the processed data arrived.

Massa is the PI on a 19-th episode *IUE* (1996) key project along with co-Is A. Fullerton and A. Feldmeier (Max-Planck, München), R. Prinja, I. Howarth, A. Reid, and K. Smith (UC London), S. Owocki, and S. Cranmer, (Bartol Res. Inst.), J. Nichols (CSC), A. Kaufer, O. Stahl, and B. Wolf (Landessternwarte Heidelberg-Königstuhl, Germany), and W. Waldron (ARC). The project was awarded 270 hours of observing time spanning 30 days. The object of the program is to study the modulation of stellar winds by rotation in supergiants with typical rotation periods of 10 to 15 days. Observations are scheduled for the middle of 1996.

Waldron and Corcoran (USRA) are continuing their analysis of *ASCA* SIS observations of O stars. All stars show X-ray line emission above 1 keV. However, the large iron line complex predicted by X-ray emissivity models at approximately 0.8 keV is not observed. They suggest that this discrepancy may imply noncosmic metal abundances, or may be due to uncertainties in the emissivity models (e.g., atomic data; radiation transfer effects). They also find no evidence for a high energy nonthermal distribution of X-rays which is expected to be present in a shocked stellar wind.

Waldron and Vallergera (Eureka Scientific) have been granted *EUVE* Guest Observer time to observe the early O star, ζ Puppis. Their EUV modeling efforts suggest that the strength of the EUV emission will provide a valuable diagnostic for interpreting the high energy phenomena observed in early-type stars.

Pérez, van den Ancker (Amsterdam) and Thé (Amsterdam) continued their search for potentially young objects within the emission line F-type stars. Unbiased computer searches have been carried out for objects of spectral type F,

however, only a few potential objects have been identified since limited information has been recorded in most catalogs, due to observational selection effects. There is a known, and unexplained, lack of pre-main sequence objects among F-type stars, whereas brighter or earlier stars (Herbig Ae/Be stars), and fainter or later stars, (G and K, T Tauri stars) seem to be well represented in surveys of young objects. In order to further study the sources of activity, binarity, flaring, line variability, clumpiness in the line of sight, etc. a proposal was submitted to ESO (1996 cycle) for the detailed spectroscopic study of seven of the most promising emission-line F-type stars.

2.6 Solar Physics

Zarro was awarded a Compton Gamma Ray Observatory (CGRO) Phase 5 Guest Investigator program to study solar flares observed with the Burst and Transient Source Experiment (BATSE). Zarro is using these observations to study the effects of coronal and chromospheric heating by field-aligned electric currents. The BATSE detectors provide high-sensitivity hard X-ray spectra in the 10-100 Kev range that can be used to infer the number flux of accelerated electrons and the strength of the accelerating DC-electric field. The coronal heating current is derived from the field strength by using Ohm's law. Analysis of several flares has indicated that heating by coronal currents is more than sufficient to power the soft X-ray flare and to simultaneously drive the observed upflows associated with chromospheric evaporation. However, in many cases, the predicted current heating rate can exceed the measured soft X-ray heating rate by an order of magnitude. This heating surplus may be responsible for producing the well-known superhot component in flares.

Moran continued his work at the Laboratory for Extraterrestrial Physics (LEP). He has analyzed solar IR spectra to infer magnetic field strengths using data collected by D. Deming (NASA/GSFC) and himself at the McMath telescope at KPNO. Moran is also developing an IR Fabry-Perot camera to make 2D solar magnetic field maps. The data analysis shows the height dependence of field strength in sunspots and plage, allowing a test of current solar magnetohydrodynamical modeling. The camera is ready for an engineering run at the KPNO McMath, which will take place in early 1996.

Moran also performed research involving coronal visible spectra measurements made at the Sacramento Peak Observatory using the 40 cm coronagraph. The measurements show that the largest Fe x doppler motions occur in the coldest coronal regions, indicating nonthermal motions, such as waves. These would explain the source of heating in these regions. It might also explain the power source of the high speed solar wind. the results of an earlier investigation while he was at MIT appeared this year.

2.7 Space Physics

Ghosh continued his studies of magnetohydrodynamic (MHD) turbulence and its applications to space physics. He is a co-I on an ongoing Space Physics Theory Program (SPTP) grant: The Role of Turbulence in Heliospheric Plas-

mas, Goldstein, PI. Working with Roberts and Goldstein (both NASA/GSFC). Ghosh modeled several aspects of the expanding solar wind using the three-dimensional MHD codes that he developed.

Gosh also helped to analyze *Ulysses* spacecraft observations which show strong velocity-magnetic field correlations at short wavelengths and weak velocity-magnetic correlations at long wavelengths at high solar latitudes. Ghosh demonstrated that such states are a natural consequence of MHD turbulence in the presence of large velocity shears. This result is reported in Goldstein, Roberts, & Ghosh, (1996).

It has been suggested that the Alfvénicity of outward propagating waves can decay from interactions with non-propagating pressure-balanced structures in the solar wind. Ghosh conducted simulation studies to establish that structures are not sufficient to decrease the Alfvénicity of outward propagating waves (Roberts, Ghosh, & M.L. Goldstein, 1995).

Solar wind velocity- and magnetic-field fluctuations show a minimum variance in the direction of the background (Parker spiral) magnetic field. Collaborating with Oughton (UCL, UK) and Matthaeus (U. of Delaware), Ghosh showed that similar minimum variances occur in decaying MHD turbulence at low plasma beta, but not at high plasma beta. This is one of the first indications that the compressible MHD model (low plasma beta) may better explain certain solar wind observations than the incompressible MHD model (high plasma beta). A paper describing these results have been submitted (Matthaeus *et al.* 1996).

On more theoretical grounds, Ghosh collaborated with Siregar (ARC) to show how gradients involving the off-diagonal components of the pressure tensor and the magnetic-field tensor can produce effective nonlinear viscosity and resistivity. These nonlinear dissipation functions have better computational behavior and greater physical relevance for the solar wind than standard (collisional) dissipation operators (Siregar, Ghosh & Goldstein, 1995d).

Finally, Ghosh studied the influence of the Hall term on MHD turbulence. This term is relevant in understanding solar wind spectra at scales near the ion gyroradius. Ghosh showed that the observed steepening of solar wind spectra at the ion-gyroradius scales may be due to Hall effects and not a result of wave damping (Ghosh, *et al.* 1995).

Siregar studied the effects of cyclotron interactions on the large scales in collaboration with M. Goldstein (NASA/GSFC). Understanding solar wind anisotropies in both spectra and proton and electron temperatures, as well as the spectral turnovers at the proton cyclotron frequency, requires studies of wave-particle interaction processes, usually limited to Vlasov studies, PIC or hybrid simulations. These approaches cannot address larger scale structures and turbulent cascades. Using new Vlasov moment approach to model cyclotron interactions, relationships between an effective transport coefficient, off-diagonal pressure elements, and kinetic information are studied. This development will help studies of the coupling between small and large-scale phenomena in space plasmas. This new approach is needed to understand observed anisotropies and cutoffs in proton and electron data. A paper was submitted (August 95). The authors will

continue the development of Vlasov moment approach to cyclotron interactions with focus on the effective transport coefficient and off-diagonal pressure tensor elements, spectral anisotropies, cutoffs of the nonlinear spectral cascade, magnetic helicity evolution.

The existence of high-speed flow has been long-standing puzzle for theoretical modelers because of the difficulty in obtaining the observed high speeds/high temperatures. The degree to which nonlinear magnetic fluctuations can contribute to the acceleration (in addition to the thermal pressure) is uncertain and difficult to analyze for nonlinear non-WKB Alfvén waves propagating in a realistic expanding environment. A 1-D expanding model in spherical geometry for fully nonlinear Alfvén waves with no separation of scales was developed in collaboration with Y. Lau (U. of Maryland). Low frequency waves are used with wavelengths comparable to background variations. Results show a substantial amount of acceleration due purely to long wave magnetic field contributions as well as a saturation of the fluctuating amplitudes. A paper is in preparation (Lau Y.T. & Siregar 1996).

Siregar also studied stellar wind acceleration due to long waves and static magnetic fields. Results show important modifications in the geometry of wind and accretion solutions in the presence of the magnetic field. Modifications to the Parker model near the coronal base are under study in collaboration with K. Wong (USRA).

Vortex streets are believed to exist at the interface of fast and slow solar wind streams in the outer heliosphere. A three-dimensional sustained supersonic vortex street in the presence of a magnetic shear is studied using a spectral code, in collaboration with Ghosh (ARC). The magnetic field stabilizes the formation of the vortex street, and the flows remained supersonic for several nonlinear times. Work continues in relating simulated density fluctuations with spacecraft observations.

2.8 Instrumentation

Thompson (ARC) supported the May 1995 flight of the Goddard Solar Extreme-ultraviolet Rocket Telescope and Spectrograph (SERTS). This is a sounding experiment designed to obtain spectra of the sun in the 240-480 Å range. As in previous flights, Thompson digitized the flight film and derived the film calibration curve. Software written by Wang (ARC) for *SOHO*, to select synoptic solar images and derive pointing information, was used for the SERTS target selection. The next flight of SERTS, in June of 1996, will be used to provide in-flight calibration of the CDS instrument aboard *SOHO*.

During the last year Twigg continued work on the solar diameter and shape using data from the *Solar Disk Sextant*. Results from a comparison of the 1992 and 1994 balloon flights was presented at the January AAS meeting in Tucson. Further work continues on solar diameter, shape, and limb darkening using these datasets. In addition, a recent flight of the *Solar Disk Sextant* 3 Oct. 1995 is expected to help confirm the reality of the small secular change in the solar diameter found from the 1992-1994 comparison.

Black continued his work with the Monitoring X-ray Experiment (MOXE), an all-sky monitor being developed as

one of the core instruments for the *Spectrum-X-Gamma* mission, planned for launch in early 1997. MOXE is a collaboration between LHEA (Black, Boyd and Kelley, NASA/GSFC), the Los Alamos National Laboratory, and the Russian Space Research Institute. It will monitor several hundred X-ray sources on a daily basis, and will be the first instrument to continuously monitor most of the X-ray sky, thus providing long-term light curves of many galactic as well as some extra galactic sources. MOXE will also alert users of more sensitive instruments on *Spectrum-X-Gamma* to transient activity.

MOXE distinguishes itself from other all-sky monitors by its high duty cycle, having unprecedented sensitivity to transient phenomena with time scales between minutes and hours. This duty cycle is a result of both the instrument design and *Spectrum-X-Gamma*'s four day orbit. The instrument consists of a set of 6 X-ray pinhole cameras based on imaging proportional counters. Together, they view 4π steradians (except for a $20^\circ \times 80^\circ$ patch around the Sun). With a 24 hour exposure, MOXE will have a sensitivity of about $2 \mu\text{Crab}$ and be able to locate a $10 \mu\text{Crab}$ source to better than 0.5° .

The MOXE engineering model has been delivered to the Russian Space research Institute and undergone interface tests there. More elaborate tests in the engineering model spacecraft with other instruments are currently underway. The MOXE flight instrument is largely complete. All of the electronics, including a solid-state memory that can hold 32 hours of data are finished and currently in environmental testing. All the flight detectors are complete and undergoing environmental tests and calibration. Delivery of the flight instrument to Russia is planned for late 1995.

Fixsen is collaborating with Mather (NASA/GSFC) on a Radiation Cooled Telescope. This is a test of a concept to build a telescope which would be passively cooled to $\sim 10-20^\circ \text{K}$ by radiation alone. They have built a set of nested cans to be tested in a liquid helium dewar. The cold plate will simulate the 3K temperature of space. The outside can will be heated to $\sim 100 \text{K}$ which has already been demonstrated in space by the *COBE* radiation shield and dewar. The inside can is then supposed to come to $\sim 15 \text{K}$ by radiation to the 4 K cold plate. Although this is only a test model if successful this arrangement could be useful for many infrared spaceborne systems.

Fixsen, along with Meyer, Kowitt (NASA/GSFC) has been involved with the design of the Frequency Sensitive Bolometer (FSB). If successful, this concept will open the way for a 2-dimensional array of bolometers at the focal plane of a telescope which will also have frequency discrimination at each pixel.

2.9 Mission Support and Calibration

The Solar and Heliospheric Observatory (*SOHO*) is a spacecraft designed to study the quiescent sun, concentrating on it's internal structure via helioseismology, the solar atmosphere from the chromosphere to the corona, and the origin of the solar wind. Stationed at the inner Lagrange point between the earth and the sun, it will provide an uninterrupted view of the sun. Launch is currently scheduled for late No-

member of 1995. At the Goddard Space Flight Center operations center, scientists will be able to command the satellite and view the results in real time, reacting to the changing solar conditions. ARC will provide science operations and data analysis support for several of the instruments observing the inner corona, with at least eight personnel working on the project. ARC's involvement with *SOHO* goes back over several years. Thompson and Yurow helped design and build one of the detectors for the Coronal Diagnostics Spectrometer (CDS). They, together with ARC personnel Zarro, Wang, Macwan, Moran, and Luttermoser, have developed much of the software to be used during operations of CDS and of the Solar Ultraviolet Measurements of Emitted Radiation (SUMER) instrument, as well as the centralized catalog system.

Moran developed image correction routines for the SUMER and UVCS detectors on *SOHO*. Both are UV coronal telescope/spectrographs. The routines are nearing completion. He reported on the progress of this project at the CDS/SUMER science meeting held in Oslo, Norway in Sept. 1995.

Fixsen contributed to the calibration of the DIRBE instrument on *COBE*. In particular the use of a set of celestial sources to form a final correction to the calibration and verify stability over the flight. The celestial recalibration (or smoothing) will only be used for bands 1-8 (2 μm to 100 μm). These allow for calibration drifts to be limited to <1% for all channels with the shortest wavelengths considerably better.

Massa continued his involvement with the Space Telescope Imaging Spectrograph (STIS) team. STIS is a second generation *HST* instrument which is scheduled to be installed in 1997. Massa constructed computer simulators of the instrument in various modes, and used it to synthesize expected science observations. This software package is currently being applied to science planning by the STIS team members.

3. EDUCATIONAL AND PUBLIC OUTREACH

Over the past year, Grady has been active in presenting star parties geared to lower elementary school children in conjunction with the Young School, Columbia, MD. The star parties include hands-on activities, a WWW-based "virtual" star party, and observing using a mixture of the naked-eye, binoculars, and very small telescopes from a suburban observing site. The *virtual star party* is on-line at the URL

<http://www2.ari.net/kcox/starparty.html>.

Ghosh is also the PI of an Initiative to Develop Education in Astronomy (IDEA) grant for 1994-95. This ARC education outreach project is on the topic of "Observing and Modeling Astrophysical Shocks" and introduces high school students to interactive computer simulations.

Pérez, in collaboration with Massa, has developed a company WWW Home Page which, in addition of including corporate information, also presents original research outlines of selected ongoing in-house activities (see the URL listed in our address). This means of broadcasting research activities has been used by collaborators to preview work in progress and to download material of interest, as well as, browsing for

the general public. Weaver, Massa, Odenwald, Grady and others have developed their own astronomy related Home Pages, which are currently links to the company URL.

Odenwald was awarded a book contract by the University of Chicago Press for a work entitled 'The Accidental Vacuum', which traces over 5000 years of human investigation into the nature of the physical vacuum. A much shortened synopsis of the book was written and will be published in the December 1995 Sky and Telescope magazine as their feature science article. Odenwald has also authored a WWW site called "The Astronomy Cafe" which is now among the top 5% of all sites with over 9000 visitors. Its will also be featured in two upcoming books on the top 1000 sites on the net, and how to use YAHOO. It was also featured in the PBS TV program 'ComputerWise' on 20 September 1995. Hopefully sponsorship for this education outreach resource will be forthcoming and enable him to expand its offerings. The Astronomy Cafe can be reached through the ARC Home Page, or accessed directly via: URL <http://www2.ari.net/home/odenwald/cafe.html>

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