Review Papers

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IV	Andre Blecha
V	Ian McLean
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VII	Allen Penny
VIII	Christiaan Sterken
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XV	Irina Guseva

INTRODUCTION

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ABSTRACT: A short introduction to the subject of the meeting, IAU Symposium No. 167, New Developments in Array Technology and Applications is given. CCD and Array detectors have become the detectors of choice at optical observatories all over the world. Direct imaging, photometry and spectroscopy are all vastly improved as a result. Thirteen IAU Commissions joined in sponsoring this meeting which indicates the wide interest in this subject. In the five days of the symposium the following topics were discussed: New Developments in CCD Technology, New Developments in IR Detector Arrays, Direct Imaging with CCDs and Other Arrays, Spectroscopy with CCDs and Other Arrays and Large Field Imaging with Array Mosaics. A few papers concerning Astrometry with CCDs were given in the poster sessions. Scientific results were also presented in the poster sessions.

CCD and Array Detectors have become the detectors of choice at optical observatories over the world. Direct imaging, photometry and spectroscopy are all vastly improved as a result. Recently especially dramatic improvements have been made in the area of IR arrays. Now observations are routinely made of faint and crowded objects under a wide range of wavelengths that one could not even consider measuring before the advent of CCDs. The accuracy of photometric and spectroscopic measures has increased dramatically. However, some of the papers at this symposium point out that there are still problems in obtaining the highest precision from CCD observations.

The first CCDs were used in 1975 and in the 1980s they spread throughout the astronomical community. Now almost all the direct imaging done at optical telescopes is done with some form of array detector. In view of these developments it was felt that the XXII General Assembly would be a good place for a discussion of New Developments in Array Technology and Applications. Thirteen IAU Commissions have joined in sponsoring the meeting and this number of supporting commissions is evidence of the wide interest in this subject by the astronomical community. In the five days of the symposium we will discuss the following topics: New Developments in CCD Technology, New Developments in IR Detector Arrays, Direct Imaging with CCDs and Other Arrays, Spectroscopy with CCDs and Other Arrays and Large Field Imaging with Array Mosaics. A few papers on Astrometry with CCDs will be given in the poster sessions, as will papers on hardware, software, techniques and scientific results.

I made a tabulation in A&AA of all the references listed under CCD (---) in the subject index for volumes 25 to 57, covering the years 1979 to 1993. The number of references plotted in Fig. 1 is a lower limit to the number of articles on CCD techniques and results. Not all the CCD articles are indexed under a CCD heading. But the plot gives a good indication of the

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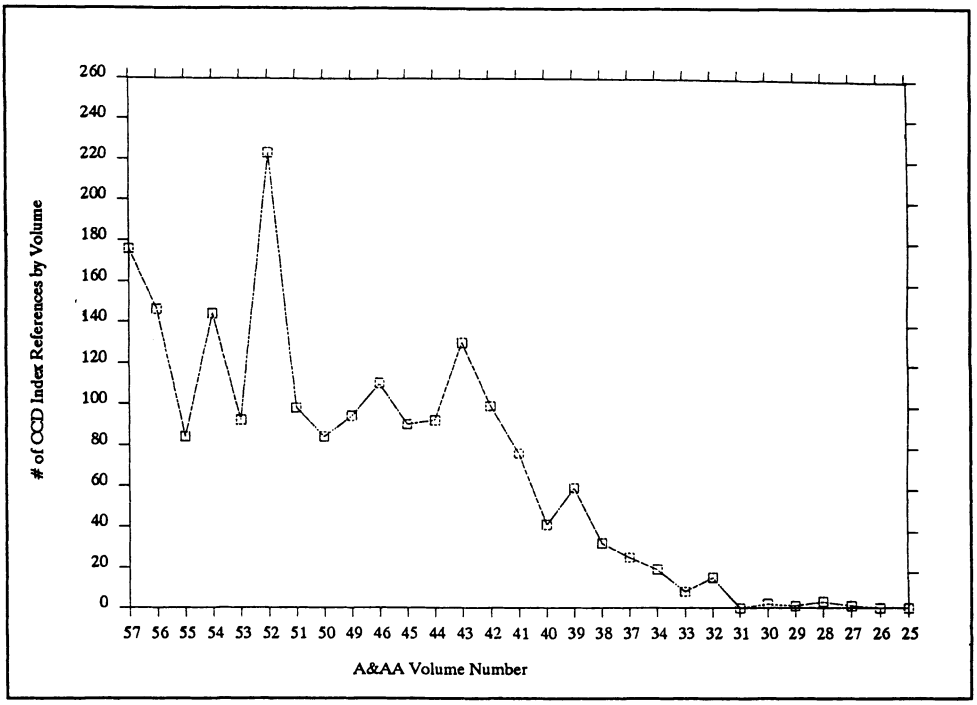

Fig. 1. The number of Index CCD References in A&AA Volumes (1979 - 1993)

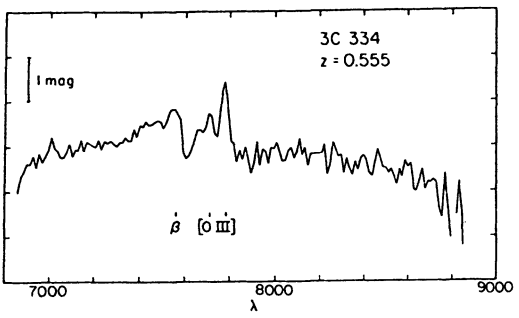

Fig. 2. A CCD spectrum of the quasar 3C 334 (from Oke 1978)

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TABLE 1

A List of Some CCD Meetings (1979 - 1994)

21 - 23 Nov., 1979, ESO Workshop on Two Dimensional Photometry, at Noordwijkerhout, The Netherlands, P. Crane and K. Kjar, eds.
10 - 11 June, 1981, Solid State Imagers for Astronomy, at Harvard Smithsonian Center for Astrophysics, Proceedings SPIE 290, John c. Geary and David W. Latham, eds.
8 - 10 Sept., 1981, Instrumentation for Astronomy with Large Optical Telescopes, IAU Colloquium No. 67, at Zelenchukskaya, USSR, Colin M. Humphries, ed., D. Reidel, Dordrecht
8 - 10 Mar., 1982, Instrumentation in Astronomy. IV., at Tucson, Arizona, David L. Crawford, ed., Proceedings SPIE 331
7 - 9 Sept., 1993, Instrumentation in Astronomy. V., at London, England, Alec Boksenberg and David L. Crawford, eds., Proceedings SPIE 445

22 - 23 Aug., 1985, Solid State Imaging Arrays, at San Diego, Cal., Keith N. Pettyjohns and Eustace L. Dereniak, eds., Proceedings SPIE 570
4 - Mar., 1986, Instrumentation in Astronomy. V., at Tucson, Arizona, David L. Crawford, ed., Proceedings SPIE 627
17 - 19 June, 1986, The Optimization of the Use of CCD Detectors in Astronomy, at Haute Provence, France, J. -P. Baluteau and S. D'Odorico, eds., ESO Conf. and Workshop Proc. No. 25
21 - 24 Mar., 1988, ESO Conference on Very Large Telescopes and Their Instrumentation, at Garching, Germany, M. -H. Ulrich, ed.
6 - 8 Sept., 1989, CCDs in Astronomy, at Tucson, Arizona, George H. Jacoby, ed., ASP Conf. Series, Vol. 8

15 - 17 Mar., 1990, CCDs in Astronomy. II., at Charleston, South Carolina, A. G. Davis Philip and Saul J. Adelman, eds., L. Davis Press, Schenectady
25 - 27 Feb. 1991, Charge-Coupled Devices and Solid State Optical Sensors. II. at San Jose, Cal., Morely M. Blouke, ed., Proceedings SPIE 1447
7 - 9 June, 1991, IEEE Charge-Coupled Devices Workshop, University of Waterloo, Waterloo, Canada, Savvas G. Chamberlin, organizer
27 - 30 Apr., 1992, Progress in Telescope and Instrumentation Technologies, at ESO, Garching, Germany, M. -H. Ulrich, ed.
15 - 17 Nov., 1993, Calibrating the Hubble Space Telescope, at STScI, Baltimore, Maryland, J. Chris Blades and Samantha J. Osmer, eds.

13 - 14 Mar., 1994, Instrumentation in Astronomy. VIII. at Kona, Hawaii, David L. Crawford and Eric R. Craine, eds., Proceedings SPIE 2198

rapid increase of CCD literature in the last decade and a half.

A search was made to find meetings that were mainly concerned with CCD Technology from 1979 to 1994. Table 1 (on page 5) lists 16 meetings for which proceedings have been published. Other workshops have been held with no proceedings published. The list in Table 1 will serve as a guide for persons interested in following developments in this field.

The earliest CCD result that I came across during my search was a paper by J. B. Oke (1978) in the Journal of the Royal Astronomical Society of Canada which showed CCD spectra taken of the quasars 3C 380 and 3C 334 in the wavelength region 7000 Å to 9000 Å. A copy of the spectrum for 3C 334 is shown in Fig. 2.

The first commercially available chips were made by Fairchild which made chips up to 488 x 380 pixels with noise levels of 30 electrons. Texas Instruments made a 400 x 500 thin chip with noise levels of 10 -15 electrons. RCA came out with a 512 x 320 pixel, back illuminated chip. By 1980 TI was making 800 x 800 pixel devices. By 1985 the noise level was down to 4 - 15 electrons. In each of these devices the silicon circuit stores electrons produced by the photons incident on the chip as charge. At the end of the exposure the charge is moved to the edge of the chip, row by row, where it is read off.

In the mid 1980's IR arrays appeared (32 x 32 pixels). In 1987 buttable CCDs were being designed as a way of increasing the size of the detector. In 1989 Jacoby, at Kitt Peak, was able to report that CCD detectors were being used in 97% of the optical observations, up from 2% in 1979 (Jacoby 19990). Now the standard chip at many observatories is a 2048 x 2048 pixel chip. Chips of 4096 x 4096 pixels have been made but the success rate is not nearly as high as a run of the 2048 x 2048 pixel chips. Mosaics of chips have been made as a way of increasing the size of the area of sky which can be investigated. Chips are being treated to increase the UV sensitivity. Thinning, backside charging, antireflection coatings are all techniques for increasing the sensitivity of CCD chips.

The largest telescopes can now make measures of faint objects with accuracies impossible to obtain with the earlier technology. And telescopes of modest aperture can do work that used to be done only by the largest telescopes. Small observatories and amateur astronomers can do research work of high quality - so the improvement in observing techniques has been an improvement across the board, for all investigators involved in astronomical observations. As many people have pointed out, the CCD is the "People's Detector".

At this meeting we will learn of CCD activities at the large telescopes, new developments in infrared arrays, advances and concerns with CCD photometry and spectroscopy, developments in the creation of large mosaics and related topics. We will begin with the opening paper of the scientific sessions, by Sandro D'Odorico of ESO with his talk on Array Detectors for the ESO Very Large Telescope. Before he starts I would like to express my thanks for his efforts as co-chairman of the SOC and the great help he has given me in organizing this conference. Thanks are also due to ESO which provided the abstract booklets containing the abstracts of the invited review papers and of the poster papers and support to bring my secretary, Mary Bongiovanni to The Hague to take care of the transcription of the discussion following each paper.

REFERENCES

Jacoby, G. H. ed. 1990 in CCDs in Astronomy, ASP Conf. Ser. 8, p. ix
Oke, J. B. 1978 Journal of the Royal Astronomical Soc. of Canada 72, 121