THE APPLICATION OF OPTICAL ARRAYS TO SOLAR SYSTEM AND STELLAR PROBLEMS

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Unprecedented activity exists in very high angular resolution astronomy at optical wavelengths. Applications of telescope arrays to modern problems have been described in publications too numerous to list here. For illustrative purposes, we shall here consider an array with a maximum baseline of 350 m corresponding to a limiting resolution at the first visibility null of about 0.3 milli-arcsec at 550 nm wavelength.

For solar system applications, such an interferometer would be capable of resolving structures as small as 200 m from a distance of 1 a.u. The imaging of minor planets could be carried out for thousands of these objects pending instrumental sensitivity limits. The Galilean satellites would be resolvable with more than 20 million resolution elements showing details less than 1 km across. Pluto and Charon could be inspected with 9 km resolution. These exciting possibilities may be somewhat remote from present analysis capabilities, but the feasibility of imaging highly extended objects with low surface brightnesses must also have seemed remote to the pioneers of radio aperture synthesis imaging.

Multiple telescope arrays will be the premier instruments for stellar astrophysics during the coming decades, their applications to extragalactic astronomy being somewhat more problematic due to sensitivity considerations. The angular diameter of a star when combined with the measured integrated flux from the entire photosphere yields the emergent flux at the stellar surface. Emergent flux, or its equivalent, effective temperature, is the basic parameter describing stellar radiation, required in many fundamental theoretical and observational applications. These data, when obtained in large samples as functions of spectral type, luminosity class, metallicity, rotation rate, etc., will provide a powerful means of testing model atmospheres. Measurement of angular diameters provides the only means of directly determining effective temperatures, except for the relatively small number of eclipsing binaries with accurately measured parallaxes and well-determined linear radii. Equally important is the calibration of temperature sensitive photometric indices, thus effectively extending the method to distances as great as the particular index can be measured. Davis has shown that diameter accuracies are required at the $\pm 2\%$ level if a solid calibration is to be applied to indices such as the $(B\text{-}V)_o$ scale.

Along the main sequence, the interferometer could resolve arbitrarily large samples of stars for all spectral types except for the very hottest and coolest stars. The rarity of O-type stars is the limitation although there are some 15 resolvable O stars, primarily in the southern sky. Success with M-type dwarfs is a question of sensitivity. For main sequence stars with types ranging from B to K, hundreds of stars of each class are readily accessible. Thousands of cool giants and supergiants are resolvable out to kpc-scale distances.

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Arrays will resolve the photospheres of variable stars exhibiting radial and non-radial pulsations. Scores of Cepheids and Mira variables and hot stars such as the Beta Cephei stars will be resolved. The direct calibration of the Cepheid period-luminosity relation follows from the careful combination of interferometric and spectroscopic results. The extended atmospheric phenomena associated with Be stars and with Wolf-Rayet and P Cygni stars will be directly observable. For these complex structures, or for detecting rotationally induced oblateness, it is important that arrays offer good two-dimensional u-v coverage.

Binary stars play a fundamental role in observational astrophysics by providing the only direct means of measuring stellar masses, quantities that, with initial chemical composition, determine the entire course of evolution for a star. In spite of the fact that tens of thousands of binaries have been discovered, measures are accurately known for only some fifty systems. This situation is due to the largely non-overlapping selection effects among the various techniques for observing binaries, each technique being individually incapable of extracting the masses. By basing the empirical mass-luminosity and mass-radius relations upon masses with errors of $\pm 15\%$, as we are now compelled to do, sensitivity to fine structure due to differing metallicity, core rotation and main sequence evolution is largely lost. There exists essentially no information on the masses of extreme metal-poor stars and only the barest of data pertaining to highly evolved, disk population stars.

Telescope arrays will revolutionize binary star astronomy by eliminating the gap now separating the visual and spectroscopic binaries. At 100 pc, a 350 m array could resolve a 2 $M_\odot$ binary if the period exceeds 12 hours, corresponding to a semi-major axis of only 0.016 a.u. This same system could be resolved at 1 kpc with a period as short as 16 days. Most promising will be the resolution of double lined spectroscopic binaries for which individual masses and the distance to the system will be derivable. This offers the possibility for directly measuring distances well beyond the practical cut-off of trigonometric parallax. Full two-dimensional u-v coverage is necessary to extract the orbital inclination, the crucial information that is lacking from spectroscopy. Of the 978 systems in the spectroscopic orbit catalogue of Batten, Fletcher, and Mann, 683 binaries, or 70% of the entire catalogue, would be resolvable by the array. For many systems individual diameters will also be resolved, providing cases in which all the basic physical parameters for a star will be measurable. Applications to binary star studies are almost boundless. Surveying with new degrees of completeness, imaging the rich variety of phenomena associated with close binaries, measurement of apsidal motions, and the astrometric detection of very low mass companions come to mind.

These brief examples show but a portion of the almost limitless possibilities for modern high resolution optical astronomy.