The Presidential Address

FUTURE TRENDS IN STELLAR SPECTROSCOPY

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It is customary on these occasions that the President of the Society gives an address on a theme in which he has been actively engaged in the recent past. I shall, therefore, spend the next half hour, in giving you an account of what in my opinion are the likely future trends in stellar spectroscopy that will improve our comprehension of the physical conditions in stellar atmospheres as well as of the kinematical characteristics of the stars.

A hundred years of stellar spectroscopy have indeed widened our horizons in astronomy very significantly. We have today reliable methods of temperature and luminosity classification, a self-consistent system of line-of-sight velocity measurements and the means of evaluating abundances and physical conditions in the atmospheres of most stars, within our easy reach. Indeed, we have a minimal information on the spectral characteristics of almost every different kind of object we are aware of today in the heavens. The future will undoubtedly witness, not only a manifold degree of comprehension on these objects but also an increase of our horizons of awareness of many hitherto unknown species of the constituents of the Universe. The new approaches being made in both theory and observation herald the rapid ushering in of such a possibility. And in my view, a major change in our conventional exeprimental methods of study is a dire necessity to attain this goal.

To begin with, let me consider the sampling of objects to fainter limits to serve a two-fold purpose. Firstly, such studies can increase our lists of the different species overwhelmingly, from which we can make a choice for detailed study. There is also the very important feature of being able to pick out newer types of objects with characteristics unfamiliar to us today and which may play very important roles in our future understanding of stellar evolution and cosmology.

With the advantage of hindsight, it seems easy to assert that when the wide angle Schmidt telescopes of sizeable aperture came into use in the late forties and early fifties, if we had the vision to plan a spectral survey to a fainter limit than the usual tenth or eleventh magnitude, we would have most certainly become aware of the spectral peculiarities of the quasistellar objects, and anticipated their subsequent discovery by at least a decade. Lying concealed and still well within our reach from magnitude eleven to twenty are a vast variety of objects, some of which may have features of which we are unaware even today. To discover these objects should be our first concern, for they may pose problems that will revolutionize much of our thinking.

In principle, what one needs is an extension of the comprehensive approach of the Henry Draper Catalogue to the limit of a magnitude or two brighter than that of the Palomar survey. This is, however, not a goal easily reached in practice. Crowding of faint spectral images is an obvious difficulty with the faster objective prism cameras of wide angle. And besides, sheer light gathering power will be the basic need for stars fainter than the fifteenth or sixteenth magnitude, if one adopts the conventional values of dispersion utilized for classification.

I see a ray of hope in this mammoth task, only if we agree to adopt a different style altogether. Our dependence on the two-colour aspect of the Palomar atlas has been significant in the recent past, when we have employed it to advantage in matters of identification of objects picked up in the X-ray, infra-red and radio regions of the spectrum. The principle we thus employ is to utilize the information provided by a combination of response of the photographic plate and the energy distribution in the continuum of the object under study. The Palomar atlas provides a lower limit of information of this kind, with photographs only in the blue and in the red. The advantages are obvious, if instead, we could know the energy distribution over a major portion of the spectrum that can be photographically registered. And it is here that microspectra seem a major possibility. For, when we give up the idea of seeking information from the absorption or emission lines in the spectrum and instead depend only on a knowledge of the continuum, we can decrease the dispersion used to such low values wherein we still can get the continuum distribution without losing heavily on image concentration on the plate, and thereby limiting magnitude. If whole-sky coverage by this technique were done by a wide angle camera comparable in light gathering power to the Palomar Schmidt, we could gather information on continuum strengths of objects to the nineteenth magnitude. We could then pick out the QSOs, peculiar blue objects, red stars, besides many others of even a kind we are ignorant of today.

The need exists, besides the above approach, to adapt conventional low dispersion spectroscopy to sample a few selected regions in considerable depth. Something like a modern version of Kapteyn's Selected Areas is what one needs to do on a restricted scale. Areas of size twenty square degrees near the galactic poles, the intermediate latitudes and near the galactic plane would be ideal for such surveys to the faintest limiting magnitudes possible with telescopes of good image scale and field. With the large-aperture Ritchey-Chretian instruments that have fields of a square degree, such an effort of low dispersion slitless spectroscopy with transmission gratings near the focal plane should not be any time-consuming task.

The measurement of line-of-sight velocities has played a very important role in our understanding of stellar kinematics. The Lick system continues to be the most complete and homogeneous survey of radial velocities that we have today. The need to extend this to fainter objects and those of a special kind for any special purpose is obvious. While statistical treatments may advocate a wholesale survey to a particular limiting magnitude, careful selection of certain species like the O and B stars, the Cepheids and the supergiants for velocity measurement would ensure specific goals, as the study of spiral structure, have a reasonable chance of achieving concrete results in a limited time interval. To do all this by conventional techniques would be most time consuming. New procedures, like Griffin's extension to the stars of Evershed's positive on negative method, or the further development of the Image dissector super scanner, and the SEC Vidicon, all make the prospects attractive, even on current standards of feasible telescope time investments.

In stellar spectroscopy of today, measuring accuracies of a half kilometre per second represent the best we strive to achieve, commonly. The time has come when we should improve this by an order of magnitude comparable to accuracies available currently in the solar case. A few sporadic efforts with the aid of Fabry-Perot interferometers have shown the feasibility of such procedures. Numerous problems of the interstellar medium, such as the fine structure of interstellar absorption lines caused by absorption within multiple cloud complexes, and isotope ratios, await solution when such high resolution techniques become common place.

In the last decade of solar research one of the major achievements has been the experimental study of convective phenomena and their consequences in the atmosphere of the sun. Techniques in solar spectroscopy have always banked heavily on the abundance of available photons for such study and hence have always been ahead of their stellar counterpart by a wide margin. With the adequacy of resolution that present-day optical technology can provide, the prospect seems bright that we should detect time-variant changes in the Doppler shifts in the integrated spectrum, of a magnitude comparable to the solar case. If the solar pattern is typically average in characteristic and degree, the relevance of such observations as a measurable parameter of stellar evolution becomes an interesting prospect.

Finally, I shall dwell briefly on absorption line spectrophotometry. We have cautiously moved from the typical dispersion values employed in qualitative stellar spectroscopy to higher values, principally obtained with the coude instruments. These have given us the crude first results in our efforts to get at quantitative values of stellar parameters. We have progressed little beyond this stage of coarse study, with little information available on line profiles other than of the Balmer series. Resolutions have hitherto been employed for "fine" analysis of stars that we have seldom used even in our first studies of the solar atmosphere. The restraint has not come from the lack of means to achieve such a resolution. It has probably originated from the subconscious tendency that we have always had in stellar research that a technique when adopted must be capable of extension to several stars of different faintness.

The brightest stars in the sky, at least the ten brightest ones, can profitably be studied by techniques of very high resolution. Amongst themselves they cover a range in spectral type and luminosity that provides a variety of greatest interest to theoretical interpretation. It should be our aim to attempt on these stars the standards of precision that is the common byword in line profile measures made today in solar reserach. Line profiles, with low scattered light-contamination levels as are obtained with monochromators in tandem or grating spectrometers employed in the double pass mode, should usher in sophistications in theoretical interpretation with realistic boundary conditions. The developments in our interpretative approach of stellar atmospheres of the next decade will undoubtedly depend heavily on the availability of such information.

To sum up, I believe that we find ourselves in possession of a repertoire of facilities that keep us poised on the threshold of major break-throughs in measurement and interpretation in the field of stellar spectroscopy. The future is splendidly bright and holds forth immense promise of vistas of accomplishment in this fascinating area of the study of electromagnetic radiation from the stars.

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Report on the Fifth Lunar Conference

The Fifth Annual Lunar Science Conference was held at the Johnson Space Center, Houston, March 18-22, 1974. Being the first post-Apollo conference, it distinguished itself from the previous meetings by a transition from a mission oriented data reporting to a problem oriented research. Consequently, several myths, generally accepted before, could not sustain the crucial scientific enquiries. Most noteworthy was the discovery of early condensates in the 4.6 billion year old lunar rock, a dunite breccia, which pushed the lunar history back by at least 400 million years and together with the simultaneous discovery of several 4.2 billion year rocks brought the 3.9 billion year "Lunar Cataclysm" earlier postulated by the Caltech group, to some question. The same group from Caltech showed that the generally accepted belief that most meteorites have a "magic age" of 4.6 billion years is not true by showing two lithic fragments in achondrite Kapoeta to be only 3.6 and 3.9 billion years old and Nakhla only 1.3 billion years old. Both these meteorites were taken to be very old, having been shown to contain primitive Pu^{244} fission xenon. In addition, Kapoeta, containing track and gas rich grains, irradiated before compaction of the meteorite body, should now be taken as a proof that compaction of meteorite bodies is a continuing process in the solar system. Essentially, these results brought the lunar and meteorite chronologies to a serious revision.

Like the ages, earlier conclusions about lunar structure was also questioned. The consensus was in favour of an inner 700 km radius core (asthenosphere) close to its melting temperature, a surrounding 1000 km shell of mantle material and the top 60-100 km thick crust of the moon, the upper 20 km being the basaltic material. Sources of various exotic components on the lunar surface were identified as follows: Anorthosites up to 40 km, KREEP source at 60 km, high aluminium mare basalt—100 km, high titanium basalts—150 km, Apollo 12-15 type basalts 250 km, source of green glass—300 km.

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