# Current Research Profile

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In the late 1950's the University of Malta was still the preserve of "professional" degrees: Medicine, Law, Theology Architecture. Bachelor degrees were mere staging posts on the way to lofty heights. By expressing a preference for technical drawing over dissection of frogs, I had unwittingly joined the Architecture stream, even if my main interests were physics and mathematics.

So when the opportunity to study abroad arose through a Rhodes Scholarship, I had no regrets in ditching Architecture, in the teeth of the most strenuous opposition of the then-Dean.

At the time university physics - a subject in the arthritic grip of the medics - was of such a level as to rule out any chance of moving into postgraduate work after a first degree here. So, at Oxford I had to read physics at first degree (B.A.) level for two years before embarking on a third year designed to lead to a B.Sc. This latter was a post-graduate degree, in fact the Oxford "probationary" D.Phil at the time.

My doctoral work was in Astrophysics and specifically in solar astrophysics (Thesis title: Photoelectric Solar Spectroscopy). At the time Oxford astrophysics was engaged in producing a refined working model of the solar photosphere - the lowest lying visible layers of the solar atmosphere - in order to establish a standard set of element abundances in the sun. Such an abundance set was required as a template for studies of nucleogenesis in those generations of stars between Big Bang and the sun's birth. The nuclear physical processes of element creation from hydrogen and helium had been set out in the classic review article of Burbidge, Burbidge, Fowler and Hoyle in Rev. Mod. Phys. 29 547 (1957).

Part of my contribution to the Departmental programme consisted in the setting up of a large grating spectrometer designed to yield observations limited only by photon noise. Large, state-of-the-art replica gratings were tested on the Fizeau interferometer at the National Physical Laboratory at Teddington. Concurrently, I was writing a computer code for deriving element abundances from observations of absorption lines in the photospheric spectrum. Things came together in the third summer with a series of high quality observations of atomic and molecular absorption lines in the photospheric spectrum. Most of the thesis material was published in three papers, one of which was of joint authorship with my supervisor Professor D.E. Blackwell.

I spent the two years following the completion of my doctorate running a high altitude solar station Oxford had established in the Swiss Alps (Zermatt). The telescope and spectrometer were among the first examples of computer-controlled instruments, with automated data collection and reduction. A second version of the combined telescope -spectrometer was designed to take spectra from sunspots, with small contamination of light from the much brighter surrounding photosphere. In such a situation one needs to keep a sunspot image (some 4-5 mm across) steady on the spectrometer entrance aperture against movements caused by (terrestrial) atmospheric irregularities. This was achieved by projecting an image of the spot on to the tip of a pyramid and balancing the output from four photomultipliers looking at the faces. Error signals were sent to a secondary mirror in the vertical telescope. The mirror was magnetically floated and had significant response up to 100Hz - more than enough to cope with the atmospheric image oscillations which have a peak amplitude at around 10Hz. There was a final filter of unwanted photospheric light. The total intensity in the 1000 samples making up one spectrum scan was determined. If found higher than a pre-set value the sample was rejected. Under good conditions, integration times of a few minutes produced the best sun spot spectra available at the time (1970). The major weakness of the instrument was its inability to determine polarisation directions in sunspots, where magnetic fields of 0.3 - 0.4T are routinely present.

A long series of papers on photospheric and sunspot spectra resulted from this work. Molecular species identified in sunspots included hydrides like SiH, MgH and CaH, oxides like TiO and even a first detection of $H_2O$. Because of the C:O balance on the sun carbon species like CN, CH and C2 could be observed more easily in the photosphere despite the higher temperatures. Lower sunspot temperatures favour the formation of CO, the most stable carbon diatomic molecule.

By the time of my return to Oxford, both the Department and the U.K., astrophysics community had set in motion a significant investment in instrumentation /facilities for stellar astrophysics. As a result I gradually shifted over to stellar work, a tendency which was reinforced by my appointment as Radcliffe Travelling Fellow at Balliol College in 1974. The main thrust of investigations involved observation of spectra of the oldest existing stars in the Galaxy. Lone exemplars of such stars can be identified by, among other properties, orbits which carry them far outside the plane of the Galaxy. But the most obvious old star groups are the globular clusters: spherical agglomerations of stars with $10^6$-$10^7$ members.

Although most old stars are well over a hundred times fainter than the faintest star visible (<u>not</u> from these islands!) to the naked eye, by the late 1970's telescopes and associated detectors (GaAs photomultipliers, image intensifiers, CCDs) had developed sufficiently to allow the collection of high quality spectra of faint sources. Of course, such observations could not be carried out from the U.K. So the planned programme involved travel to distant parts, starting with an obligatory sojourn at the Radcliffe Observatory in Pretoria, South Africa. There followed a series of visits to observatories in the US (Texas, California) and Chile, interspersed with excursions to Tenerife and Australia. The basis for these visits was an allocation of telescope time between fixed dates. There was no insurance against one's allocation being blotted out by bad weather: a rather nerve-wracking way of doing science, this.

The results from this work carried out in collaboration with Bernard Pagel of the Royal Greenwich Observatory were published in a number of papers in the U.K. Monthly Notices of the Royal Astronomical Society and the European Journal Astronomy and Astrophysics. Perhaps the most important result to emerge was the discovery that the brightest stars in globular clusters were suffering significant mass loss. This led to modifications in their computed evolutionary tracks and therefore in age estimates for globular clusters.

In 1983, I returned to Malta from the U.K., for the next seven years working as physics teacher, Deputy Headmaster and then Headmaster of the Sacred Heart Convent School. In July 1990, I joined the Physics Department of the University of Malta.

Aside from the normal teaching duties, my current 'research' interests centre on alternative energy devices, and specifically on electric and other non-polluting means of transport. Together with members of Engineering departments we are running an electric car in order to establish a baseline for local operation. At the same time we are looking into possibilities of using photovoltaics to supply energy for transport both directly by charging batteries and indirectly through electrolytic production of hydrogen. Some work on use of hydrogen in internal combustion engines has been done, but this application is intended to be a major field of action in the near future.

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