THE ARMAGH-DUNSINK-HARVARD TELESCOPE: FROM DREAM TO OBLIVION

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Abstract: The Armagh-Dunsink-Harvard (ADH) Telescope was an instrument with a checkered history that, unlike many telescopes that have a productive life of many decades, has now all but faded from memory. Nevertheless, its story is worth telling, if for no other reason, because of the part it played in Irish and international astronomy in the crucial years following the Second World War.

Keywords: Baker-Schmidt Telescope, Armagh, Dunsink, Harvard, Boyden Observatories

1. INTRODUCTION

Astronomers in Ireland in the 19th century had facilities second to none and they made important contributions to the emerging disciplines of cosmology, solar physics and stellar photometry. However, as the land tenure system in Ireland was revolutionised around the turn of the century with tenant farmers now freeholders, the landed gentry, deprived of their rental income, could no longer afford to support private observatories. Even public observatories, such as Armagh, founded in 1790 by the Church of Ireland Archbishop, Richard Robinson, and Dunsink, founded in 1783 by Trinity College, Dublin, were to some extent funded by land entitlements and could no longer afford to employ staff or buy the new equipment so essential for their daily work (Butler, 1990; Bennett, 1990). By the beginning of the Second World War, Dunsink and all the richly furnished private observatories were closed and there was only one professional astronomer on the whole island, namely Dr Eric Lindsay at Armagh. One of his recognised achievements was his part in the setting up of a large Schmidt telescope, the ADH, in South Africa.

2. THE GENESIS OF THE ADH TELESCOPE

Lindsay had been at the Harvard southern station, Boyden, for three years in the mid 1930s, working as an assistant to Dr J.S. Paraskevopoulos. In November 1937 he moved to Armagh to take over the directorship of the Observatory there, an organisation which at that time was, for all intents and purposes, a one man show. Whilst at Harvard and later at Boyden, Lindsay had become familiar with the revolutionary new Schmidt telescope design and was aware of its benefits for an observatory such as Harvard with its traditional involvement in stellar surveys. Shapley, the director at Harvard, conscious of the lack of large telescopes in the Southern Hemisphere, initially planned to convert the 60-inch Rockefeller Telescope at Boyden to a *Super-Schmidt* system. However, Bart Bok, then at Harvard, and Lindsay, by now living in Ireland, preferred a new Schmidt telescope. Together with Shapley, they dreamed up a plan to build a new telescope in which Armagh would share observing time and costs with Harvard (Bok, 1943). During the following years, both Lindsay and the Harvard astronomers became heavily involved in the war effort, with Lindsay attached to the British Admiralty and Bok engaged in teaching navigation. There was little time for astronomical research and the provision of new telescopes was an impossible goal. Finally, in April 1946, with the Second World War behind them, Shapley (1946a) wrote to Lindsay with some rough dimensions for the telescope optics and concluded “All this is fun to work and dream on - spectra, spectrophotometry, variable stars, standard photometry, galactic structure, nebulosity’s - gosh!” At last, the project could move forward, now with the newly reopened Dunsink Observatory an additional prospective partner.

A chance encounter between Shapley and the Irish Prime Minister, Eamon de Valera, at Shannon Airport (Shapley, 1946b, 1953), played its part in advancing the case for the ADH. Shapley together with some astronomical colleagues was marooned in Shannon by fog en route to Copenhagen and De Valera was awaiting the arrival of a party of Bishops from Rome. De Valera, who had been a student of Edmund Whitaker at Dunsink in his youth, was keen to encourage original research in mathematics and allied sciences in Ireland and had already founded the Dublin Institute for Advanced Studies for this purpose. Shapley, recognising De Valera, introduced himself and proceeded to discuss some of Lindsay's ideas for the reopening of Dunsink and the joint telescope project with Harvard. De Valera was not in a position to give the go ahead on the ADH there and then and it took some time and effort for him to win the support of the other members of his cabinet but it is evident from Shapley's description of the event that he was able to convince De Valera that Harvard was fully behind the project. Shapley, now more confident that the new telescope had a good chance of success, took advantage of an opportunity just six weeks later, to buy for less than $2,000, a Pyrex blank for the 36-inch primary mirror (Shapley, 1946c).

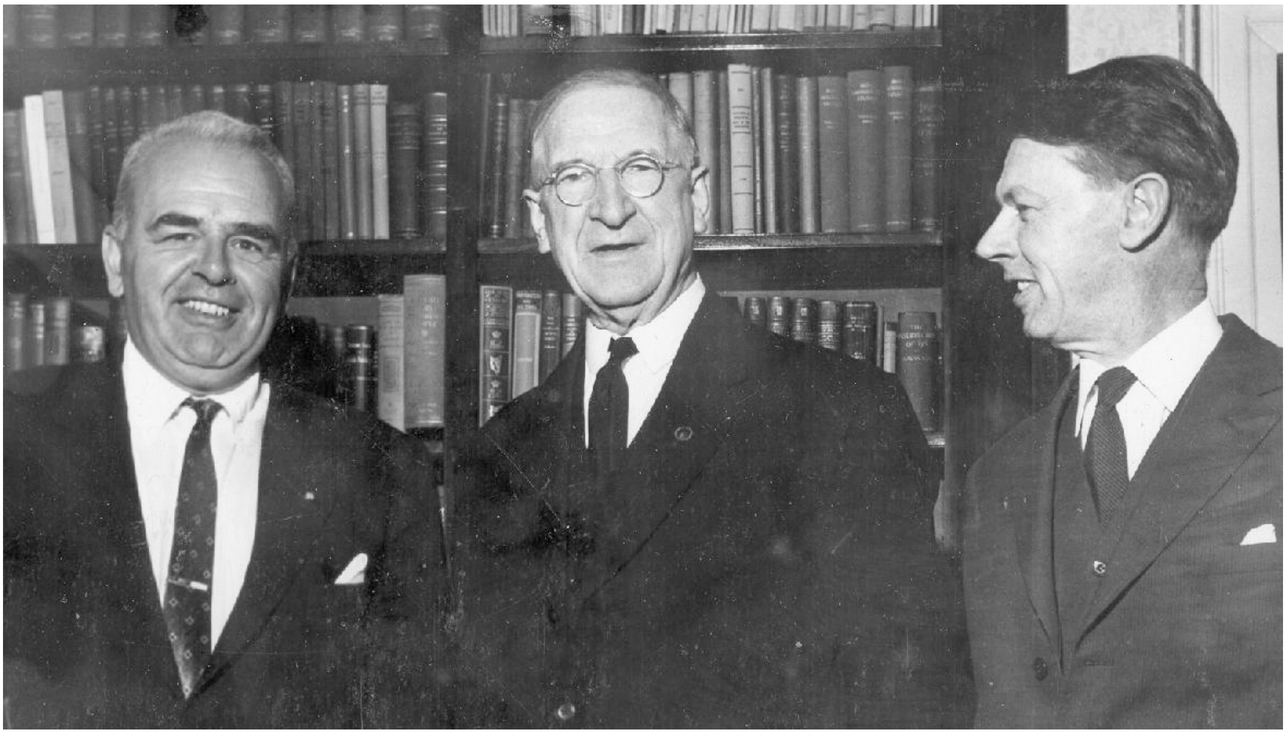

Figure 1. Bart Bok (left) and Eric Lindsay (right) with Eamon de Valera (centre) Taoiseach (Prime Minister) of the Republic of Ireland 1937-1948, 1951-1954 and 1957-1959. (circa 1961, *Photo courtesy of P. Corvan)*

Meanwhile, in Ireland, Lindsay was pressing the authorities, north and south, to support the project as part of the revitalisation of Armagh and Dunsink Observatories (Bennett, 1990). Early in February 1947, Lindsay (1947) wrote that the legal advisors to the two governments had met "for the first time ever" to confirm arrangements. Throughout these negotiations, there were some reservations regarding Harvard's long-term commitment to the project. Harvard would not accept permanency in its support for the ADH. In retrospect, this apparent lack of commitment should have rung alarm bells with Lindsay. However, it seems not to have done so, or at least if it did, he kept any reservations to himself. The signing of the ADH Agreement by the Archbishop of Armagh, representing the Board of Governors of Armagh Observatory, the Registrar of the Dublin Institute for Advanced Studies and the President of Harvard College in August 1947 represented a major achievement for Lindsay and in retrospect was a milestone in cross-border cooperation in Ireland. Quoted by Shapley (1948a), Dr D. MacGrianna, Registrar of the DIAS, wrote:

> We are certain that the new telescope, as an instrument, and mounted as it will be in the southern hemisphere, will provide our newly re-opened Dunsink Observatory with material of the highest value for fundamental astronomical research. In the close collaboration which, we are happy to note, will exist between the three observatories in the running of the telescope, we may see perhaps the first instance on a small scale of the establishment of one of those international observatories which, apart from their immediate astronomical advantages, are to serve the cause of goodwill among nations, and in whose establishment your astronomers are taking such a prominent part. We are looking forward to the erection of the Armagh-Dunsink-Harvard Telescope which will add another happy link to the many which bind this country to the United States.

The way was now clear for this new collaboration between the scientists of Ireland and the USA and De Valera likewise was impressed that the coming together of the two Irish governments had been for an "intellectual project".

3. THE DESIGN, CONSTRUCTION AND ERECTION OF THE ADH TELESCOPE

Bok and Shapley with James Baker soon got to grips with the finer details of the design for the new telescope which was to be a two mirror Cassegrain Schmidt with a 0.9m spherical primary, a 0.43m spherical secondary and a corrector plate of 0.8m aperture. The design produced a flat field with a plate scale of 68"/mm. In January 1948, a contract price was fixed with the Perkin Elmer Corporation (Shapley, 1948b) and by the summer of 1949 the telescope was nearing completion. After tests at the optical works (see Figure 2) by Bok, it was packed for transport to South Africa. The cases arrived in Bloemfontein in October 1950 and within two months, the telescope had been placed on the former mounting of the Bruce Telescope (Figure 3), which now had to support almost twice the weight it had previously. This problem was further exacerbated by the later addition of an objective prism and its associated counterweights. With a drive, that was already rather worn in some places, the decision taken for financial reasons, to place the ADH on an old mounting, proved to be a mistake that would haunt the telescope for the rest of its active life. Another 'saving' that was to prove detrimental to the telescope's performance was the run-off roof commonly used by Harvard. This required that the telescope be left in a horizontal position when not in use, with the optical elements supported on their edges and gradually deforming under their own weight. This was most likely the cause of the increase in astigmatism as the telescope aged.

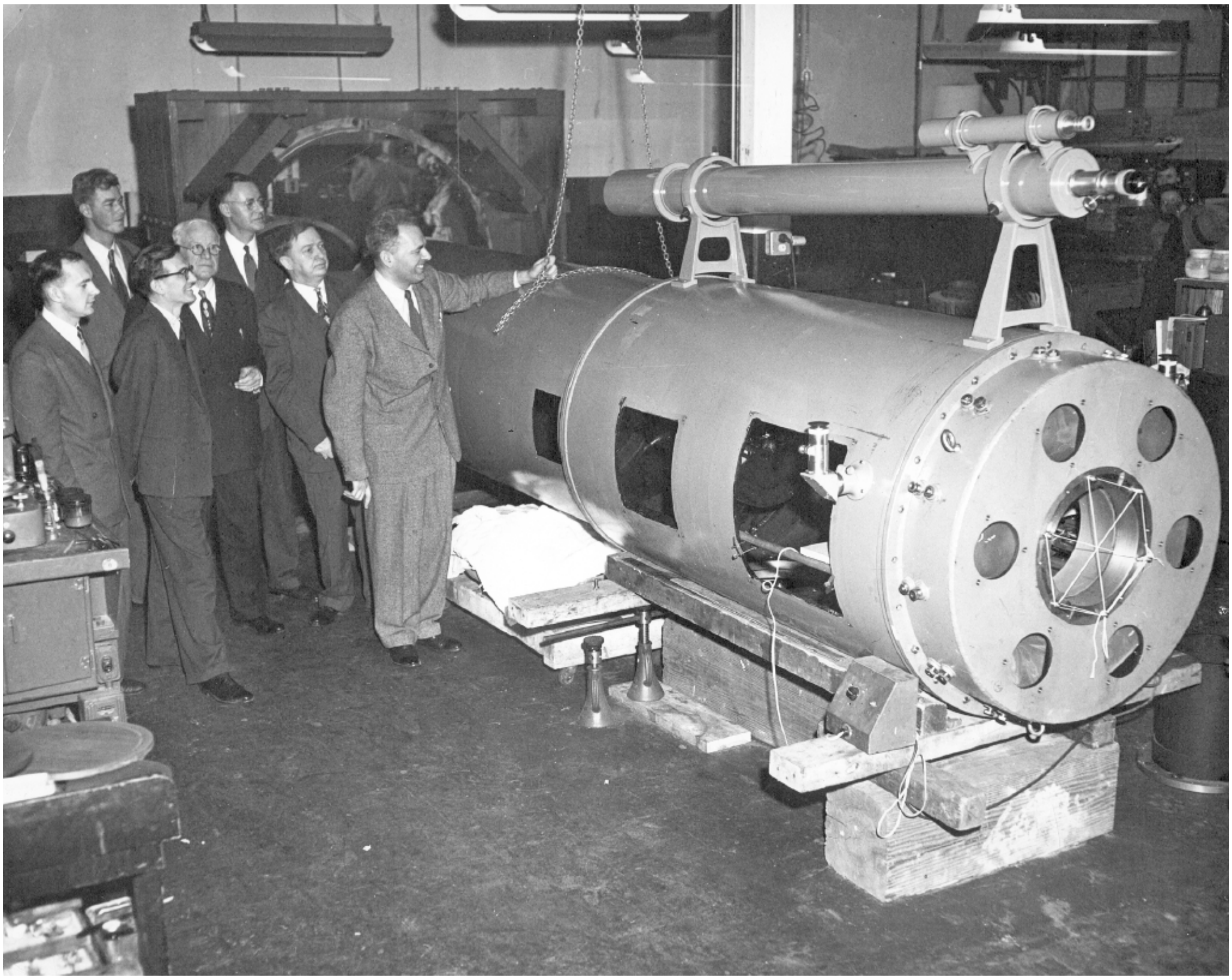

Figure 2. The tube of the ADH telescope at the Perkin-Elmer Coporation's works (Feb 1950). From left to right, standing by the telescope are: Kevin Rush, Irish Consul in New York; Peter Lindhorse, South African Vice Consul; John Dawson, British Vice Consul; Charles Elmer and Richard Perkin, co-founders of Perkin-Elmer Corporation; Harlow Shapley, Director of Harvard Observatory; Bart Bok, Associate Director of Harvard Observatory. (*Armagh Observatory*)

4. EARLY OBSERVATIONS AND PROBLEMS WITH ALIGNMENT

But, these problems were for the future. Early exposures with the 10-inch diameter round plates taken by Bok had excellent quality stellar images and everyone was delighted. Lindsay (1953) published a paper demonstrating to all the exceptional capabilities of the ADH, which truly seemed to usher in a new era in Southern Hemisphere astronomy (See Figure 4). One of the projects considered at this time was to supplement, with ADH plates of the southern sky, the Palomar Sky Survey, then underway in the Northern Hemisphere. However, with photographic plates at $2 each and the proportion of exposed plates that were of good quality probably less than half, it was quickly realised that a budget way beyond that available to the ADH partners was required. The National Geographic Society, already committed to the Palomar Schmidt, turned down a request for funding. In spite of this setback, observational programmes were initiated by all three partners; with Armagh and Harvard cooperating on a survey of the Galactic Plane and a survey of southern galactic clusters started by Dunsink. Bart Bok and Paul Hodge from Harvard, Eric Lindsay from Armagh, and Hugh Butler and Gordon Thompson from Dunsink, all travelled to Boyden to take up their allocations of telescope time.

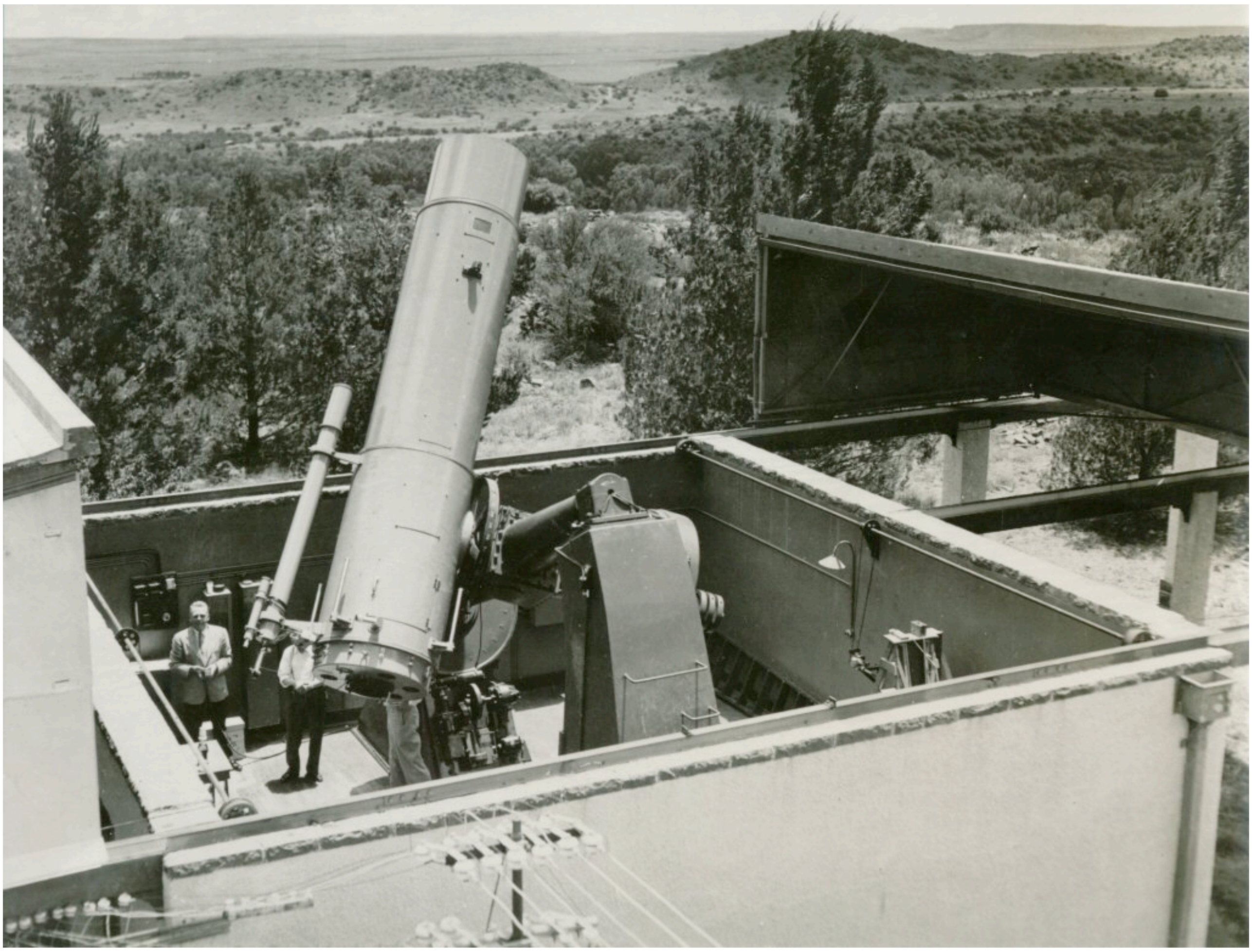

Figure 3. The ADH Telescope erected at Boyden Observatory. Bart Bok stands to the left, facing the camera. *(Armagh Observatory)*

It was during these early years of the telescope's working life that the first indication of problems with the ADH surfaced. First, there was the problem of the rapid change in focus, mainly due to the large temperature drop that occurs shortly after nightfall at Boyden during the clear winter season. This can be easily 15-20 °C in a couple of hours. Bok alleviated this problem substantially by fitting a knife-edge test device, however with the focus changing so rapidly even this could not ensure good focus over a long exposure of 30 to 60 minutes. The worn drive was responsible for other problems, including the occasional floating of the telescope near the meridian. Yet more difficulties arose with the stability of the optical alignment. With three optical elements and a plate holder to consider, it was not easy to construct a procedure that ensured all were correctly centred and adjusted relative to the optical axis. Though the alignment had been good when Bok and Paraskevopoulos first installed the telescope, later observers found it difficult to re-establish this level of perfection once an optical component had been adjusted. Both Hugh Butler and Eric Lindsay seem to have had such problems and eventually rumours got abroad that all was not well with the ADH. Attempts to overcome these problems occupied the visiting astronomers for the first two or three years after the installation of the telescope. However, they were soon to be overshadowed by a bombshell that arrived on Lindsay's desk in Armagh from the new director of Harvard Observatory, Donald Menzel, (Menzel, 1953).

5. FUNDING THE BOYDEN OBSERVATORY

Menzel's letter stated that the closure of Boyden Observatory was imminent and Harvard was to withdraw from its operations in South Africa. Lindsay was devastated by the news, not only for Irish astronomy, but also because of the enormous personal efforts he had made. It was the ultimate betrayal and he blamed Menzel, whom he believed had never been a friend of Boyden. In addition he felt completely let down by his old *alma mater* Harvard. After his exhaustive efforts to convince the two Irish governments to support the ADH, now the principal partner, whose prestige was so important to them, was pulling out. There was some suspicion that the teething troubles with the ADH and the detrimental rumours passing amongst American astronomers, were a part of the background to the decision. His suspicions were confirmed a month later when Bok reported that Sergei Gaposchkin had returned from Pasadena with the news that the astronomers there had told him “the ADH is no good” (Bok, 1953).

Figure 4. The Eta Carina Nebula as it appears on ADH plate No H20. *(Armagh Observatory).*

Lindsay wrote to Harvard, expressing his extreme disappointment and asking the Harvard authorities to reconsider their decision. He raised the possibility of UNESCO funding for Boyden, following a suggestion by Bill McCrea some years earlier of a *United Nations Observatory*. Bart Bok, as always in touch with events, replied that it was most unlikely that Harvard would reconsider, however they were prepared to give a breathing space (until June 1954) for efforts to find US or foreign institutions willing to take over. After initial proposals by Bok and Lindblad, then president of the ICSU and a former president of the IAU, and with no concrete proposals a year later, Harvard, frustrated by lack of progress, eventually gave 31 December 1954 as the absolute deadline for a takeover. A meeting in Hamburg was hastily arranged between Harvard personnel and representatives of several European countries including Germany, France, Belgium, Sweden, The Netherlands, and Ireland. Lindsay was in South Africa at the time so Hermann Brück, director of Dunsink, represented both Irish observatories. Brück who knew many of the continental astronomers involved from his early years in Germany had taken an active part in bringing them on board. It was agreed that three countries would take over the running and financing of Boyden, namely: Belgium, Sweden and Germany. The two Irish observatories were initially not expected to provide financial support due to their ownership of the ADH, however, subsequently, they did become contributors. Harvard, on the other hand, now that it was relieved of its financial obligations, continued its involvement in Boyden until its interests were taken over a few years later by its sister institution in Cambridge, the Smithsonian Astrophysical Observatory.

With the future of Boyden now secured, a new complement of Continental astronomers now had access to the facilities of the observatory. In particular, Swedish astronomers from Stockholm who were active in galactic structure research made observations with the ADH. Amongst the original stakeholders of the ADH, however, changes were afoot. In 1957, Bok moved from Harvard to become director at Mount Stromlo and Brück moved to the Royal Observatory Edinburgh, to be followed shortly by several other former staff members at Dunsink, including Michael Smyth, Gordon Thompson, then in Cambridge, and Maire Brück. Hugh Butler had already moved to Edinburgh. The new director at Dunsink, Mervyn Ellison, was a solar physicist and, although he never broke the connection with Boyden, he did not use its facilities. In Armagh, Lindsay, now troubled by health problems, ceased to observe, though he continued his work on Magellanic Cloud emission regions with ADH spectral plates. With its recent history of problems, the ADH had an uncertain future. However, a revival of interest was shortly to take place.

6. NEW PROCEDURES FOR THE ALIGNMENT OF THE TELESCOPE AND FOR PHOTOMETRY

David Andrews, who joined the staff at Armagh in 1963, quickly became immersed in observations with the telescope and was to play an important part in its continuing story (see Andrews, 1998). After the death of Paraskevopoulos in 1951, no permanent successor was appointed by Harvard to the Boyden directorship. First Bok then Lindsay acted as temporary superintendent of Boyden's activities on Harvard's behalf. This tradition of temporary appointments continued into the Boyden Council era. In 1964/5, it was the turn of Jean Dommanget from the Observatoire Royal de Belgique. Dommanget was an enthusiastic observer and together with Andrews, took a fresh look at the alignment problems of the ADH.

The original method devised by Perkin Elmer fixed the position of the secondary mirror with respect to the primary using a metal measuring rod and centered it by sighting its edge through the hole in the centre of the primary. Though, when first carried out by Bok and Paraskevopoulos, this procedure appeared to work well, later attempts by others were less successful. The Dommanget and Andrews procedure, on the other hand, used the flat side of the corrector plate as its fundamental reference surface. Using a small centering telescope mounted on three adjustable feet, the secondary and primary mirrors were viewed through the lightly figured corrector plate (see Figure 5). The alignment procedure proceeded step by step, first centering the secondary with respect to the corrector plate, next adjusting the tilt of the primary and the secondary, and finally the plateholder (Andrews and Dommanget, 1965). A further test developed later by the author used out of focus images to confirm when alignment was complete. With this procedure, the alignment of the telescope could be quickly checked and adjusted and the way was open for increased use of the telescope.

Figure 5. David Andrews using the small centering telescope to check the alignment of the ADH Telescope in 1966.
(photo the author)

Another important development at this time was the arrival in Ireland from the Royal Greenwich Observatory, of Patrick Wayman who was appointed director of Dunsink after the death of Ellison (Wayman, 1987). Wayman was an expert in the Schmidt-Cassegrain design and had made a thorough study of its potential whilst a research student in Cambridge. He pointed out that the large secondary mirror of the ADH, with a diameter half that of the primary, gave rise to substantial vignetting beyond the central 1 degree field. This was a significant deficiency of Baker's design and one that had been seriously underestimated by him in his initial calculations of the telescope's performance. (Baker, 1947). Wayman visited Boyden in 1964 and decided to base Dunsink's main observational programme there. After discussions with Michael Feast at Radcliffe Observatory, he proposed an observational programme on Cepheid variable stars in the Magellanic Clouds. The Magellanic Clouds, the nearest external galaxies to our own, are a stepping stone to the more distant Universe. In late 1964, the author moved from Edinburgh to Dunsink to join Wayman in this project.

Conscious of the need to measure faint stars in the Magellanic Clouds that could not be seen in the eyepiece of the 60-inch telescope, Wayman designed an offset photometer head that could be used either to measure faint cepheids directly or to provide photoelectric sequences to calibrate ADH plates. An initial survey by the author suggested that the best approach would be to establish a number of sequences containing stars in the range 12-18 magnitude near to the centre of the ADH fields and to make zero-point corrections with respect to this central area to correct for vignetting. An extensive programme of observation to obtain the U,B,V,R photoelectric magnitudes of standard stars in three areas, one in the SMC and two in the LMC, using the offset photometer on the 60-inch telescope was undertaken in 1965/6. During the same season about 100 ADH plates of reasonable quality, in four colours, were obtained of each region.

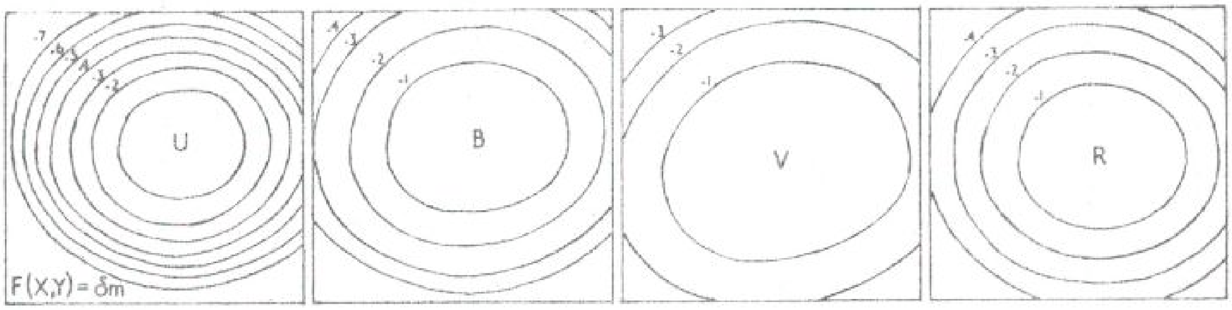

Figure 6. Averaged contour diagrams of the position dependent correction for vignetting and focus f(X,Y) determined by Butler's method from ADH plates. Contours are at intervals of 0.1 magnitude and are different for each colour. *(from Andrews, 1971)*

A comprehensive reduction routine (Butler, 1972) for the calibration of ADH plates was developed and implemented on the IBM 1620 computer at Dunsink Observatory during 1967/8. This was basically a multiple regression routine to establish the coefficients in an equation relating the standard magnitudes determined photoelectrically to the diameters of the stellar images ([?]) measured by an iris diaphragm photometer. The basic equation (eq. 1) had three parts, a polynomial in [?] (eq. 2), a position dependent part (eq. 3) which corrected for vignetting and focus variation across the plate (see Figure 6) and two further terms which were linearly dependent on the colour (B-V) of the star and the background photographic fog level.

$$V = f([?]) + f(X,Y) + f(col) + f(den) \quad (1)$$

where:

$$f([?]) = a + b.[?] + c.[?]^2 + d.[?]^3 + ...n[?]^n \quad (2)$$

$$f(X,Y) = e.X^2 + g.Y^2 + h.XY + i.X + j.Y \quad (3)$$

The procedure gave photographic magnitudes, over the whole 2.8 degree field, accurate to ~0.04 magnitude over the range V = 12-16 and ~0.1 magnitude for fainter stars, quite adequate to define the periods and light curves of the Magellanic Cloud Classical Cepheids. A programme which used basically the same techniques for a study of flare stars in the neighbourhood of the Orion Nebula was successfully completed by Andrews. These two observing programmes, undertaken with the ADH in 1965-7, involved in excess of 600 photographic plates. The success of the new alignment and plate reduction methods proved that, with care and perseverance, the ADH was now capable of fulfilling its original promise to make a significant contribution to southern hemisphere astronomy.

7. A NEW LIFE FOR THE ADH?

Another development at this time, which encouraged astronomers at Dunsink and Armagh to believe that the ADH could have a bright future, was the realisation that unlike classical Schmidt telescopes, it was well suited for new developments in electronic detectors that were destined to supersede photography. The ADH with its flat and easily accessible focus could be used without major modification for a variety of applications involving the modern generation of detectors including image tubes and CCDs. A programme by Brendan Byrne of Dunsink who, in 1971, installed a pair of large photomultiplier tubes at the focus (see Figure 7) was the first attempt to use the ADH in this way. The tubes and their associated electronics monitored the light from two ~1 degree diameter areas of the sky, one to be centred on the Galactic Centre and the other on a nearby comparison region. The object of the programme was to capture any short optical bursts which might be produced by the gravitational collapse of stars as they fell into the supposed black hole at the centre of our galaxy. In fact, in the ~200 hours of observation, no optical bursts that could be unambiguously identified as from a gravitational event were detected (Byrne, 1974). Though this programme did not exploit the imaging capability of the ADH, it represented a pioneering use of the telescope. A later proposal by Hawkins and Butler to place a McMullan Spectrocon Image Tube at the focus of the ADH did not materialise, though this detector was used on the 60-inch at Boyden.

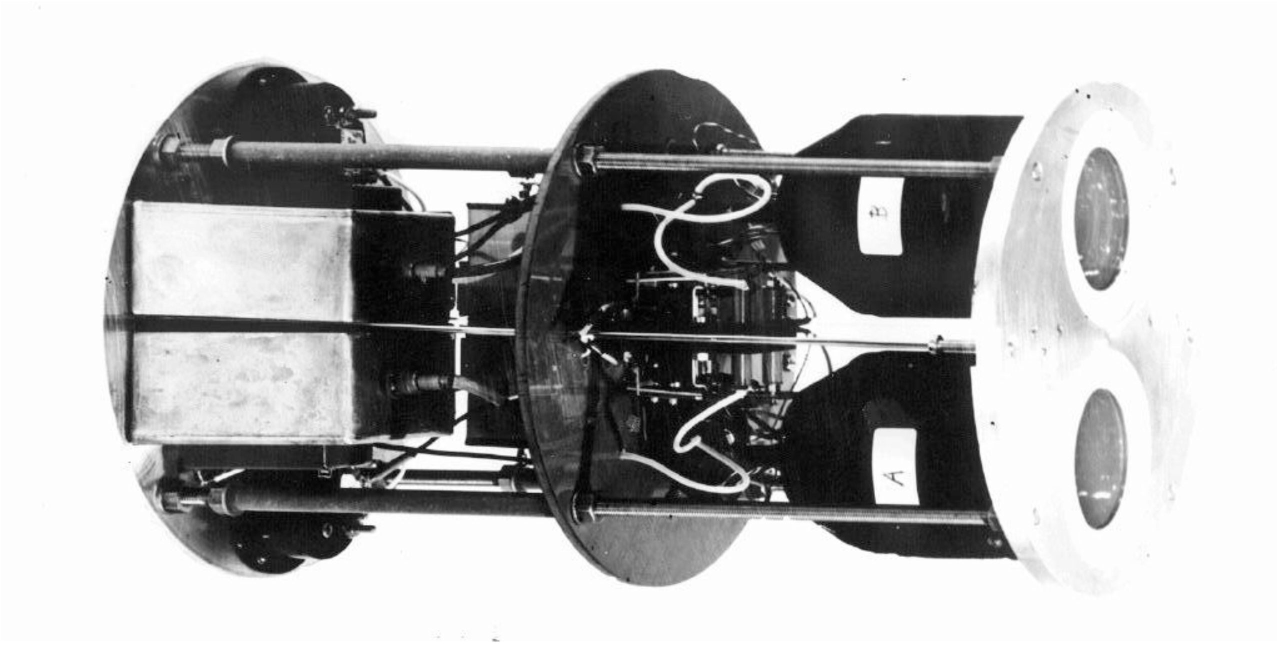

Figure 7. The twin photomultiplier assembly used by Brendan Byrne with the ADH to search for optical bursts associated with gravitational events in 1971. *(Courtesy of Mrs G. Byrne)*

With brighter prospects for the ADH, Wayman was asked by the Boyden Council to prepare a report on its condition and make suggestions for its improvement. In his report of December 1973, Wayman (1973) outlined the many problems associated with the telescope and how each one could be overcome. In general, it was an optimistic report in that the benefits from further investment in the telescope would probably outweigh the difficulties and expense. A renovation along the lines he suggested would require: (1) a new mounting and drive, (2) a proper dome or turret in which the telescope could be stored vertically when not in use, (3) a redesigned tube with focus correction, and (4) a new cell for the primary mirror with dynamic edge support. Other suggestions of a more minor nature would complete the exercise. In fact the Boyden Council was not able to commit funds at that time and none of these modifications were carried out. Nonetheless, a modification of the existing run-off roof to allow the ADH to stand vertically with the roof closed, was implemented with the result that the primary mirror now rested horizontally when not in use. This appeared to significantly reduce the astigmatism of the primary mirror.

8. BOYDEN OBSERVATORY AFTER 1970 AND THE REMOVAL OF THE ADH

Once again, however, any long-term plans for major improvement were thwarted by more intractable administrative and political considerations. By the mid-1970s, after the Smithsonian had finally relinquished all remaining US interests, it was evident that the Continental European partners in Boyden had decided to withdraw from operations in South Africa in order to join the new European Southern Observatory in Chile. In 1976, they formally left the Boyden Council, with only the two Irish observatories and the University of the Orange Free State (UOFS) remaining. With mounting political pressure at home for a suspension of co-operation with South African institutions and the difficulty in maintaining a viable facility at Boyden, in 1978, the two Irish observatories finally left the UOFS the sole occupier of the Boyden Observatory. During the previous decade, whilst Boyden was in decline, astronomical facilities which were jointly operated by international consortia, had become the norm. While the UK and Australia set up the Anglo-Australian Observatory, the UK and Spain - the Roque de los Muchachos Observatory in La Palma, ESO was steadily accumulating more participating countries from Europe. These observatories were provided with new telescopes and the latest ancillary equipment at a cost well beyond the resources available to Boyden.

With the eclipse of Boyden, it was decided by the Irish observatories to remove the ADH telescope and offer it to any other observatory, North or South, which would accommodate it, in return for a small amount of Irish observing time on the re-erected instrument. Initially, Mexico was interested to rebuild the telescope in its new observatory in Baja, California, then Brazil, Uruguay and finally Yugoslavia. However, once they became familiar with the history of the telescope and the costs of renovation, all subsequently lost interest. The telescope's optics were removed in 1981 and shipped to Ireland to await a decision on their new home. Sadly, this decision never came and the optical elements have remained in storage at Dunsink, ever since.

One final addendum to our story. In August 2004, the author, after observing at the South African Astronomical Observatory at Sutherland, visited Boyden which is now thriving once more as a research and educational facility. Sadly, nobody there remembered the ADH telescope, only an apocryphal story about the remains of the dismantled telescope falling from the back of a lorry and rolling into the scrub on the side of Harvard Kopje on its journey to the scrap yard. The telescope, for which there had been such great expectations, had met an ignominious end. It was reminiscent of a failed attempt by another Armagh director, Thomas Romney Robinson, a century earlier, to revolutionise southern hemisphere astronomy with the Great Melbourne Telescope built in Dublin by Thomas Grubb in 1869. After a similarly troubled life, with its full potential never realised, this pioneering instrument finally came to grief in January 2003 in a major bush fire at Mount Stromlo Observatory, Canberra.

9. THE LEGACY OF THE ADH

Though the working life of the ADH telescope is now over, its memory remains. It made significant contributions to Southern Hemisphere astronomy, in particular to studies of the Magellanic Clouds, Galactic Structure and southern clusters. The addition of an objective prism early in its career provided an unparalleled facility for southern spectral survey work which was not replicated elsewhere until prisms were mounted on the UK and ESO Schmidts a decade or more later. Astronomers from many institutions, not just those from countries which supported Boyden, used material gathered by the ADH and, in its use, it became a truly international telescope. However, from an Irish perspective, probably its most enduring legacy will be its role as a focus for the revival of Irish astronomy in the mid-20th century and the impetus this gave to international co-operation in astronomy through the foundation of the Boyden Council. Neither can we forget the small part it played in overcoming the mutual suspicions of two Irish governments at a time when they barely acknowledged each other's existence.

10. ACKNOWLEDGMENTS

We wish to acknowledge the following for permission to reproduce images: Mrs G. Byrne, Dr M. Brück, Dr A.D. Andrews, Mr P. Corvan. We thank Dr M. Brück for comments on a previous draft. Research at Armagh Observatory is funded by the Department of Culture, Arts and Leisure for Northern Ireland.

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FIGURE CAPTIONS

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