The Instituto Isaac Newton: A Highly Productive ESO-Chile Connection

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A bright occasion for Chile in 1978 was the founding of the Instituto Isaac Newton for Astronomical Research by Chilean astronomer Gonzalo Alcaíno. The Instituto, supported almost entirely by a contract with the Chilean Ministry of Education, now has for its staff Alcaíno as Director, William Liller, Associate Director and Senior Research Scientist, and Franklin Alvarado and Erich Wenderoth, Research Associates, plus a secretary. Located in suburban Las Condes in the eastern outskirts of Santiago, the Instituto offices are situated at the base of the Andes in a peaceful farmhouse surrounded by ancient trees and a rustic garden.

The primary research programme of the Instituto is the observational study of globular clusters in the Galaxy and in the Magellanic Clouds. That this fruitful field, which is providing fundamental answers to astronomical key questions, should be the Instituto's main activity was first suggested by Professor James Cuffey at the University of Indiana in the early 1960's when Alcaíno was carrying out graduate studies in astronomy. At the time, the pioneering work on globular clusters was being done at the Mount Wilson and Palomar Observatories by astronomers like Arp, Baum and Sandage, and during a visit to the Mount Wilson offices, Sandage and Alcaíno discussed the possibilities further. The decision was made: Do multi-colour photometry on the many globular clusters that lie at negative declinations (60 per cent of them south of –20°).

A few years later, in July 1968, Alcaíno was just completing an observing run on the Cerro Tololo 1.5-metre telescope when Harvard University professor, William Liller, arrived with a graduate student to begin work on the same instrument. This chance encounter grew into a close friendship between Alcaíno and Liller and led eventually to scientific collaborations several years later. In 1981–82 Liller took a year's leave of absence from Harvard where he had been for 21 years carrying out research in a wide spectrum of fields, including studies of planetary nebulae, comets, asteroids, cool stars and quasars. At the time he was working with Riccardo Giacconi and the group of investigators analysing early results from the Einstein Observatory. Liller was specifically involved in the optical identification of X-ray sources and had a keen interest in globular cluster sources. The following year Liller took early retirement from Harvard, made Chile his permanent residence, and became a regular staff member of the Instituto.

In the early 1980s, in addition to the research on globular clusters, the Instituto expanded its activities to include the systematic search for novae in the Galaxy and the Magellanic Clouds, and supernovae in nearby clusters of galaxies, a project which Liller undertook first using nothing more than a Nikon camera in the garden of his home in Viña del Mar, located on the central coast of Chile 120 kilometres west of the Instituto's offices. A further activity of the Instituto grew out of Liller's 3-month stay on Easter Island, 3300 kilometres west of the Chilean coast, where he went to set up a small NASA observatory to observe Halley's Comet. While there, he became fascinated with the many ancient temples on the Island, and that interest has developed into a broad programme of archaeoastronomy that has spread to many other Polynesian islands.

Since ESO's 1-metre telescope became operational in 1970, nearly all the Instituto's globular cluster data have been secured at La Silla. Since then, the staff of the Instituto has had approximately 450 scheduled nights of observing time and has used telescopes ranging from the 1-metre to the 3.6-metre and the NTT. It is our personal pleasure and privilege to express in the *Messenger* not only our deep appreciation for the use of ESO equipment, but especially our gratitude to Directors General Adriaan Blaauw, Lodewijk Woltjer, and Harry van der Laan for their constant support and encouragement. Special thanks are also due to our good friend Daniel Hofstadt, the current head of La Silla, as well as to all the personnel at the site.

In the following sections we describe in more detail the various programmes of the Instituto.

Globular Clusters in the Galaxy and the Magellanic Clouds

While the first telescopes at La Silla were not large, globular cluster photometry in the Southern Hemisphere was a virgin field, and many of the clusters that we worked on were being studied for the first time. It was at least possible in most clusters to reach below the horizontal branch, home of the RR Lyrae stars, thereby permitting us to derive

Figure 1: *The authors in front of the ESO-La Silla 3.6-m dome (Alcaíno at left).*

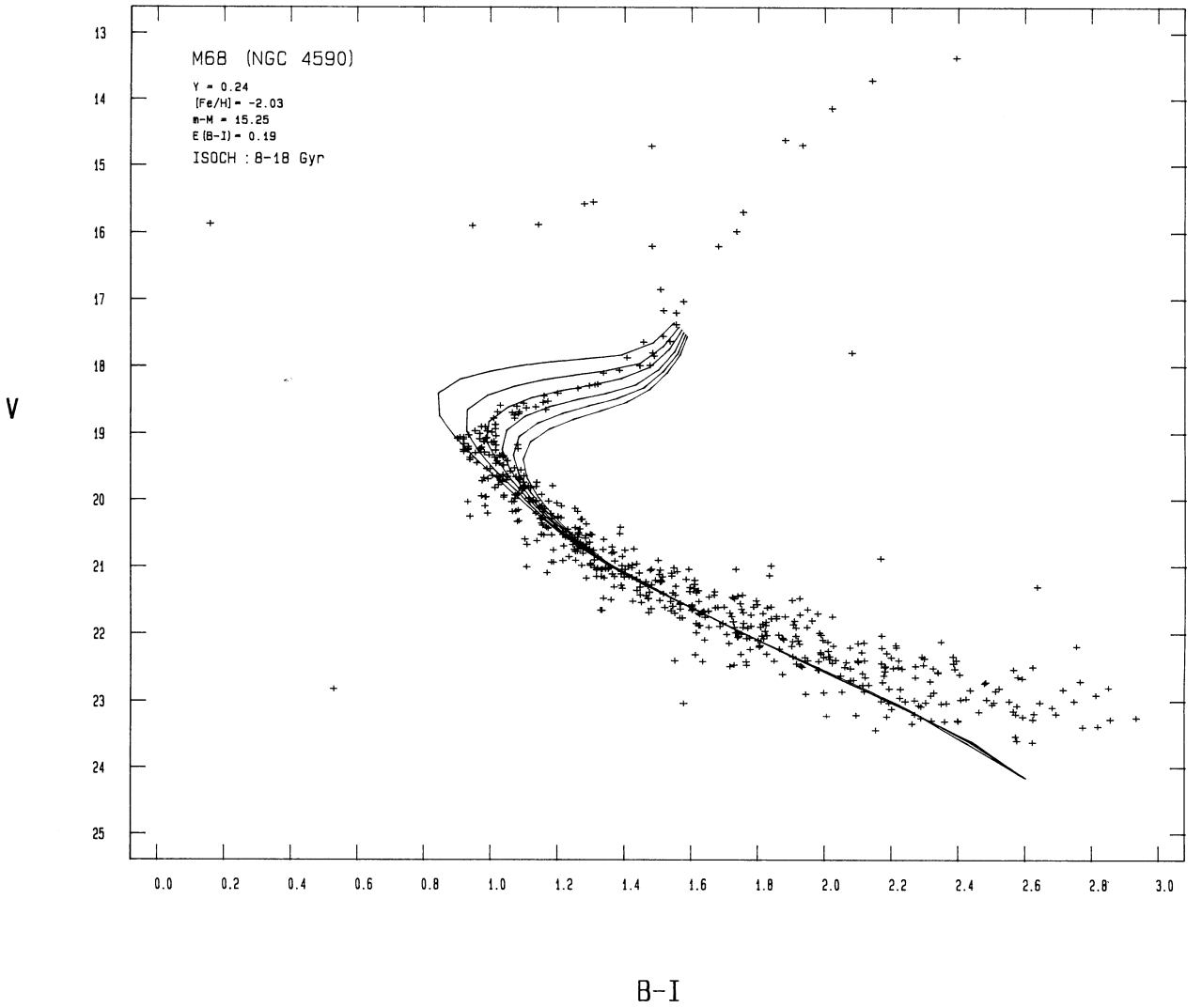

Figure 2: *The V vs. B-I colour-magnitude diagram for NGC4590 (Alcaino et al., 1990).*

reasonably reliable distances and interstellar reddenings for these objects. Also, approximate metallicities could be determined. This work culminated in the publication of the book, *Atlas of Galactic Globular Clusters with Colour Magnitude Diagrams* (Alcaíno 1973).

The early photometry was carried out arduously in several steps. First, a dozen or so stars were measured photoelectrically (UBV usually) covering as wide a range of colour and magnitude as possible. Then photographs were taken and star images measured with an iris photometer such as had been developed by Cuffey and which had been loaned to us by ESO. On some telescopes a thin-wedge prism could be placed before the objective thereby producing a second, much fainter image of each star. Thus, in a boot-strap manner, the relatively bright photoelectric sequence could be extended to fainter magnitudes.

Then came charge-coupled devices (CCDs). Suddenly it became possible to carry out photometry with substantially higher precision owing to the stability and the linearity of these marvelous detectors, especially at low light levels. Also, the sensitivity range extended beyond 1 micron making it possible to work with ease in more colours than B and V which had been the workhorse wavelength bands for many years.

One of the weaknesses of the BV system is that metallic line absorption in the blue and violet can be significant, especially for metal-rich clusters. The interpretation of observations in the context of stellar evolution theory rests heavily on model stellar atmospheres which must correctly predict the effects of this metallic absorption in stars where the metallicity is often not well known. It should be emphasized that the metallicity of globular clusters, usually expressed by the parameter [Fe/H] has a range of over two orders of magnitude. Fortunately, VandenBerg and Bell (1985) and Demarque and his colleagues have carried out the calculations needed to predict the location of isochrones in the longer wavelength bands where there is much less metallic absorption than in the blue-violet.

Other advantages are realized by working into the red and infrared: an enlarged colour baseline results which enhances effects seen less clearly and less accurately with a smaller range in colour. Additionally, observational uncertainties are reduced by having several independently derived colour-magnitude diagrams of the same cluster. With the separate evaluations of the age of a single cluster, one not only can assess more reliably the accuracy of the final result, but also can derive ages with a higher precision than attained previously or with only two colours.

Since the mid-1980s we have had

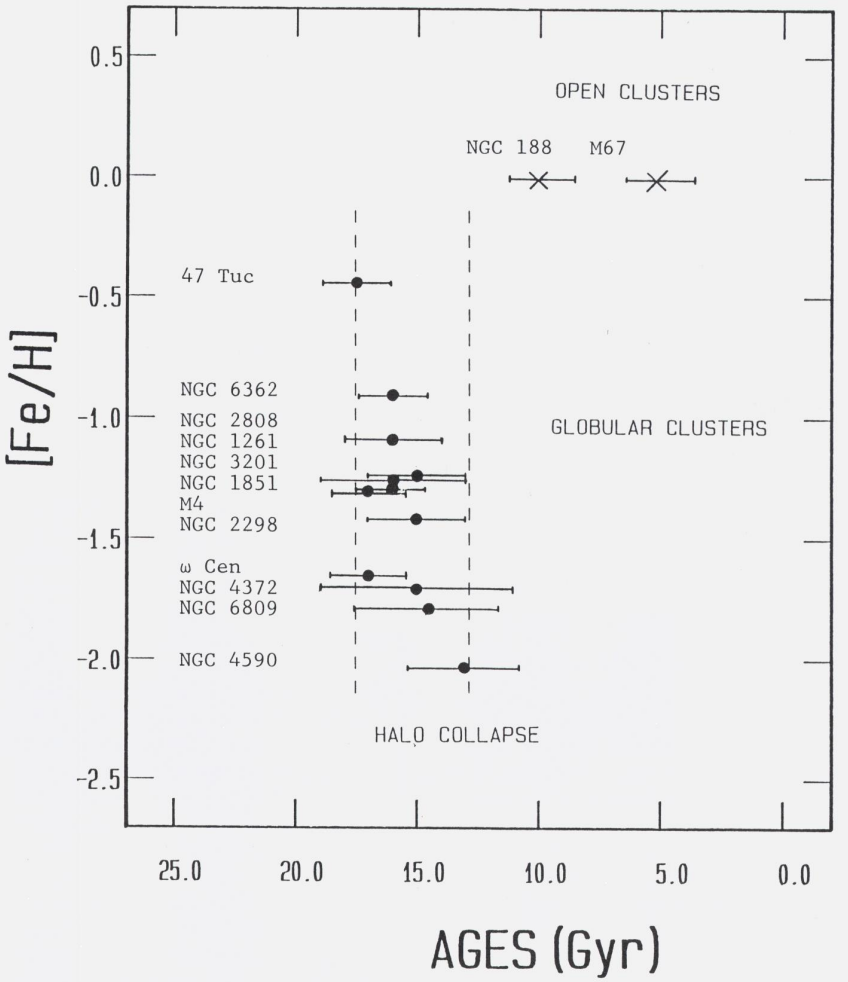

Figure 3: *The age versus metallicity of the galactic globular clusters that we have so far analysed, plus these same quantities for the two oldest known open clusters, M67 and NGC 188. It can be seen that the ages derived for all these objects are 16 ± 2 Gys equivalent to* $H_o = 61 \pm 8$ *km* s^{-1} *Mpc*$^{-1}$ ($q_o = 0$).

The majority of our cluster data has been collected with either the 3.6-m, the 2.2-m (Max-Planck), and the 1.54-m telescopes at ESO La Silla. Much of the recent observing and reduction work has been done expertly and efficiently by our colleagues at the Instituto, Franklin Alvarado and Erich Wenderoth. Besides being now very well known and highly respected at La Silla, they have often assisted others in the sophisticated data reduction techniques available to visiting astronomers.

To date we have published multi-colour results for the galactic globular clusters NGC 104 (47 Tucanae), 1851, 2298, 2808, 3201, 4372, 4590, 5139 (Omega Centauri), 5946, 6121, 6362 and 6809. We also have accumulated data for a large number of Magellanic Cloud clusters. In all we have published over 100 articles in *Astronomy and Astrophysics*, the *Astronomical Journal*, and the *Astrophysical Journal*.

One of the most significant results of this on-going research programme is shown in the accompanying figure where we have plotted the age versus metallicity of the galactic globular clusters that we have analysed plus these same quantities for the two oldest known open clusters, M67 and NGC 188. It can be seen that the ages derived for alle these objects are 16 ± 2 Gys; hence it is still an open question if the time scale of the galactic collapse was brief or as long as 4 Gys. These ages set a lower limit for the age of the Universe and an upper limit for the Hubble constant of $H_o = 61 \pm 8$ km s^{-1} Mpc^{-1}, assuming $q_o = 0$.

underway a programme of BVRI photometry of globular clusters using CCDs and the excellent reduction software (MIDAS-INVENTORY) provided by ESO. For each cluster, and using most often the ESO 1-metre reflector, we set up photoelectric standards in the same cluster fields that we intend to observe with CCDs. Thus, the effects of inaccurately known or varying atmospheric extinction are totally avoided, and errors that might arise from slightly variable exposure times are eliminated. Perhaps most importantly, valuable large telescope time is not wasted moving back and forth between widely separated fields.

Figure 4: *ESO Director General Harry van der Laan (r.) with Dr. and Mrs. Liller in front of the dome housing the 0.2-m Schmidt camera in Viña del Mar.*

Figure 5: *Liller and the NASA-loaned 0.2-m Schmidt posed in front of a moai head and altar platform on Easter Island.*

The Viña del Mar Nova Search

In April 1981 the late and highly successful comet and nova discoverer, Minoru Honda, discovered a seventh-magnitude nova in the southern constellation of Corona Australis at a declination of –37 degrees. His latitude in Japan was 33° North; Viña del Mar, Chile, is situated at 33° South. Consequently, Liller decided to take advantage of his far more advantageous location and devote spare evenings to patrolling the rich Southern Milky Way using nothing more than a store-bought Nikon camera.

This project has since grown into an extremely fruitful search programme and has expanded to include the use of a 0.2-m f/1.5 Schmidt telescope on indefinite loan from NASA. (As mentioned above, Liller had set up an observing station on Easter Island in 1986 and employed this Schmidt to photograph Halley's Comet). Today, the same Nikon camera is used to patrol the Milky Way; the Schmidt is employed to photograph on a regular basis the Magellanic Clouds and several clusters of galaxies. All the equipment is mounted permanently next to Liller's home in a small dome financed partially by the Instituto and partially by a grant from NASA. Many of the photographic supplies have been kindly supplied by the Director R.E. Williams of the Cerro Tololo Interamerican Observatory.

As of July 1992, Liller has discovered or co-discovered 15 galactic novae or nova-like objects, more than any other single person in the history of astronomy. Two additional novae were found in the Large Magellanic Cloud, one of them, discovered in April 1991, becoming the brightest nova (visual magnitude 8.7) ever recorded in the LMC. Liller (1991) has analysed the recent discoveries of galactic novae and estimates that on the average, each year in our Galaxy, some 75 ± 25 novae occur, considerably more than what Arp once estimated for our near-twin galaxy, M31 in Andromeda.

The recently inaugurated search for supernovae in nearby galaxy clusters produced its first find in January 1992, a thirteenth magnitude Type Ia SN in the S0/Sa galaxy NGC 1380, a member of the Fornax Cluster. In late 1991 the Schmidt camera was equipped with a CCD detector, and Liller has now begun to patrol the hundred or so nearest and most massive southern galaxies not located in clusters. With the CCD Liller can also do more precise photometry of novae and supernovae, thereby adding to the scientific output of this humble annex of the Instituto Isaac Newton in Viña del Mar.

Polynesian Archaeoastronomy

Shortly after Liller arrived on Easter Island in 1986 the distinguished archaeologist and Governor of the island, Don Sergio Rapu Haoa asked Liller if he would measure the orientation of Ahu Nau Nau, the magnificent ancient stone temple (with several collosal statues, or *moai*) that Rapu had recently restored. By chance, archaeologist Dr. Georgia Lee arrived a few days later with a tour group, and she in turn persuaded Liller to measure orientations of another curiosity of the island, the "sun stones" of Orongo.

These initial and totally unexpected adventures whetted Liller's appetite, and together with his Chilean wife Matilde, he began a detailed study of all of the more than three hundred temples on the island in order to discover if some had been designed to be used as astronomical observatories. Several had been considered earlier, but Liller's more thorough study led to the conclusion that over a dozen – perhaps as many as twenty – temples had been intentionally oriented with rising or setting solstices or equinoxes.

The question then arose as to whether similar results would be found elsewhere in Polynesia. Between 1987 and May 1992 the Lillers have travelled to a number of islands in the vast expanse of the Pacific Ocean – twenty so far – trips frequently made possible by support from the Instituto Isaac Newton. Of all the monuments measured to date, the best candidates for structures intentionally oriented astronomically are the massive trilithon, Ha'amonga, in Tongatapu in the Friendly (Tonga) Islands, and several long alignments of standing stones on Aitutaki in the Cook Islands, reminiscent of those found in France's Brittany. The holiest of ancient Polynesian shrines, Taputapu'atea on Rai'atea in the Society (Tahitian) Islands, and

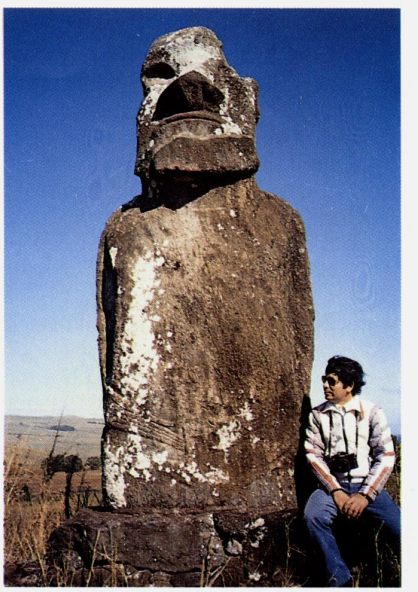

Figure 6: *The astronomically-oriented moai at the ceremonial centre of Ahu Huri A Urenga on Easter Island. The statue looks almost precisely in the direction of the rising winter solstice and a sharply peaked hill in the distance. Chilean meteorologist Julio Duarte (at right) worked with Liller at this site.*

several similar temples in neighbouring islands share a common orientation towards a rising declination of –9°. Perhaps the sun rose at that declination on the date of a since forgotten holy festival.

But of the several hundred temples elsewhere in Polynesia studied so far, few, if any others, appear to have an astronomical connection. (See Liller 1990). The people of Easter Island, called the most remote inhabited island on Earth, seem to have had a special desire to record fundamental directions.

Figure 7: *Erich Wenderoth (standing) and Franklin Alvarado analysing CCD data at the Instituto.*

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Sporty ESO

The victorious ESO Teams are feared by the competitors!

No, this is neither the translation of a phrase in a Latin reading book, nor does it refer to the technological and scientific achievements of our organization. It describes how sporty ESO staff members have repeatedly destroyed the common myth that astronomy is the realm of old men who stumble over long and white beards!

Football has always been one of our strengths and ESO teams on two continents have taught their adversaries many a lesson. ESO-La Silla tennis players are reputed to have the fastest serves above 2300 metres, and long-distance ESO-runners have been seen on many a road in Chile and Germany.

Bicycling, that noble art of ecological propagation, is in the coming, and ESO people are among the pioneers. At the ESO Headquarters just outside Garching, more and more of these elegant machines are seen, shining in all colours and in a great variety of shapes. Concerned car-drivers (a few are still left) have noticed an increasing spill-over onto the sparse parking space. New speed records are being set during the early morning race from Garching to the ESO Headquarters. And there are unconfirmed rumours that some ESO staff members spend an important part of their free time, riding along the beautiful roads in the hilly Bavarian countryside.

But nowhere has the impact been so great as in the 4th region of Chile! Read the following story to learn how the ferocious La Silla mountainbike team conquered the hearts of the Chilean public, won (almost) all of the honours at Tololo, all while representing ESO in the best possible way. Racing up (and down) the mountains in the dry Atacama desert, they have shown the world that at ESO power, transmission and response refer to more than telescopes and CCD's.

Because of the international nature of our organization, the International Astronomical Union some years ago decided that ESO astronomers participating in international IAU meetings may be registered as belonging to "ESO", rather than to a particular country.

It is at this moment not known whether the International Olympic Committee will follow this example, when the first ESO athletes show up . . . and what about the anthem?

Another Aficionado

The Other Face of La Silla

THE ESO AFICIONADOS

There used to be a time when driving a car up to La Silla one would hardly meet a living soul, and the only occasional *obstacles* of appreciable size were some donkeys. Not anymore. Several La Silla visitors and most of the La Silla staff have lately seen cyclists on the local roads, any time of the day, and going quite a bit faster downhill than uphill.

Although a solitary cyclist could be observed here and there already years ago, this activity on the present scale is new for La Silla. So what's behind the display of these hairy legs? A sudden increase of interest in a healthy pastime, or does it go further than that?

The answer is in fact better known by the amateur cyclist of the 4th Region in Chile than by many of the ESO staff and visitors. Since about a year and a half ago, these ESO mountainbikers have won all competitions that have been organized in this area.

It all started with the arrival of the mountainbikes in Chile. As a robust and all-terrain version of the traditional bike, a mountainbike is particularly well suited to wheel on unpaved roads. Although the unpaved parts of the access road to La Silla are among the best maintained of Chile, they are still unsuitable for race-bikes with narrow tires. Hence some of the ESO personnel with interest in biking brought such a mechanical piece of art up to La Silla, and a couple