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APAA

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OBSERVATÓRIO APAA

Este observatório resulta de um protocolo estabelecido entre a APAA e o Planetário Calouste Gulbenkian. Denomina-se "Observatório Comandante Conceição Silva" e encontra-se anexo ao Planetário em Belém, junto ao Mosteiro dos Jerónimos.

ÍNDICE

Fotografia da capa: Observatórios de tecto de correr | Carlos Saraiva, Rui Gonçalves e Pedro Ré

CONSTRUÇÃO DE UM OBSERVATÓRIO ASTRONÓMICO A PARTIR DE UM ABRIGO DE JARDIM

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Desde há algum tempo, tenho vindo a consultar vários sites e a visitar empresas de bricolage, na tentativa de encontrar um modelo de abrigo de jardim passível de fácil alteração, com vista à sua transformação num observatório, capaz de albergar um telescópio de pequena/média dimensão.

Mais recentemente, com a decisão que tomei de sair de Lisboa e adquirir uma moradia no campo, o desejo da edificação de um observatório tornou-se possível. Acabei por me mudar para uma moradia situada numa aldeia no distrito de Évora, possuindo um espaçoso quintal, com área suficiente para a construção do tão desejado "observatório".

Voltei assim à consulta de casas e abrigos de jardim. Existem no mercado diversos modelos construídos em três tipos de materiais, ferro zincado e aço, plástico (poliuretano) e madeira. O metal pareceu-me de difícil modificação, requerendo diversas ferramentas e uma máquina de soldadura. O modelo em plástico, mais caro que o de metal e de modificação praticamente impossível, pelo menos para os meus conhecimentos, foi também descartado. Optei pelo de madeira, apesar do seu preço ser mais elevado, mas facilmente alterável com ferramentas comuns.

As ofertas existentes no mercado nacional, na sua maioria com o *stock* esgotado no passado Verão, levaram-me a alargar a pesquisa e encontrar em Espanha um modelo de média dimensão, num site de vendas de artigos para jardim, que oferecia transporte gratuito para toda a península, com preços bastante acessíveis e madeira de boa qualidade.

Através das imagens disponibilizadas no site (figura 1), tive a nítida impressão que seria relativamente fácil, com a ajuda de umas ripas de madeira e uns rodízios fazer deslizar o teto para um dos lados do abrigo, construindo assim um clássico "roll-off-roof".

Passadas duas semanas tinha à porta um camião de uma transportadora nacional, para fazer a entrega de uma palete com 230 quilos, e um pequeno folheto com a descrição de todas as peças do kit e as instruções para a sua montagem.

Na Figura 2 é possível ver ainda parte do plástico negro, que serviu de resguardo a toda a madeira, acondicionada na palete de transporte.

Com alguma surpresa, pelas inscrições nas chapas do telhado, conclui que este abrigo apesar de o ter adquirido em Espanha foi fabricado em Riga na Letónia, e daí ser o pinho nórdico, o seu principal constituinte.

O preço deste abrigo de jardim rondou os 600 euros, bem mais económico do que a maioria dos abrigos disponíveis no mercado nacional.

Figura 1

Antes de encomendar o presente modelo, tinha escolhido outro mais pequeno que, entretanto, estava esgotado, portanto tive de aumentar a base de cimento, para poder instalar o modelo atual com 200 por 250 centímetros de área. Assim que o cimento secou, comecei a montagem das paredes, cujas tábuas facilmente foram encaixando umas nas outras, conforme se pode observar na Figura 3.

Figura 2

Figura 3

Para proceder à montagem do telhado, foi necessário adquirir no AKI de Évora as ferragens, as ripas e os rodízios, que com a ajuda de um berbequim e parafusos com porca, foi possível construir uma calha, onde o telhado assentou e pôde correr apoiado nesses rodízios (Figura 4).

Para suportar as calhas de deslizamento do telhado, aproveitei a existência de uma construção anterior (grelhador de jardim), sem ter de construir colunas para a sua sustentação (Figuras 5 e 6). Esta solução poupou-me o trabalho em betão, ou em alternativa a utilização de barrotes em madeira para suportar o peso do telhado quando este estivesse aberto.

Figura 4

A impermeabilização do telhado, construído por duas placas de aglomerado de madeira, consiste numa manta de tela asfáltica, que faz parte do kit.

Para impermeabilizar as paredes e restantes partes em madeira, apliquei um primário antifúngico (Cuprinol ou similar) e depois como isolante, um verniz aquoso acetinado, para tornar o observatório estanque à água proveniente das intempéries. Neste caso as opções são múltiplas, dependendo do gosto de cada um, quer na cor ou mesmo na textura, brilho e tipo de verniz indicado para madeiras.

Figura 5

Figura 6

Como a base em cimento é bastante permeável à água e depois das recentes chuvas, apliquei sobre o cimento uma tinta isolante de cor cinza, especialmente concebida para este fim. Em alternativa poder-se-á aplicar tinta de borracha especial para pintar o interior de piscinas, ou mesmo tinta para isolamento de telhados. Por último e depois de aparafusar ao chão a coluna do telescópio, cobri toda a área com um tapete plástico antiderrapante (Figura 7).

Figura 7

Falta-me enumerar alguns pormenores, como por exemplo a solução que encontrei, para prender o teto à restante estrutura, que é constituída por quatro fechos para cadeado, que se podem também adquirir em qualquer loja da área da "bricolage".

A instalação elétrica é constituída por um disjuntor, duas lâmpadas de iluminação (interior e exterior), um interruptor duplo e duas tomadas com terra. Para prevenir descargas eléctricas, acrescentei uma simples coluna de terra.

No mosaico de imagens (Figura 8) é ainda possível ver uma cobertura em tela de alumínio, para maior proteção à infiltração de águas pluviais.

Figura 8

Finalmente resta-me desejar, que este pequeno artigo possa contribuir para ajudar todos aqueles amadores, que se disponham a concretizar o sonho de possuir um observatório, deitando “mãos à obra” e poupando assim umas largas centenas de Euros.

OBSERVATÓRIO TECTO DE CORRER C14 – MPC 938

Rui Gonçalves

A necessidade de reinstalar e relocalizar o meu antigo telescópio C14 (que pertenceu ao Pedro Ré) – levou-me a considerar a construção de um novo observatório no quintal. O C14 esteve durante anos num pequeno observatório com apenas 1,5 × 1,5 m, situado a sul do meu primeiro observatório tecto de correr, de 3,0 × 2,0 m, que ainda hoje alberga um clássico telescópio LX200 10”. Este primeiro observatório erigido no ano 2000 sofreu uma manutenção em 2017, com a substituição de todas as suas paredes exteriores. Para substituição dos degradados painéis hidrófobos exteriores, apliquei placas de painel *sandwich*. Estes painéis existem em largura de 1 m (e várias espessuras) e são constituídos por placas de aço devidamente pintados e preenchidos com material isolante no seu interior. As placas têm um encaixe lateral perfeito. Neste “upgrade” escolhi uma espessura de painel de 3 cm, uma vez que a função de estrutura e isolamento já existia no interior do observatório, (figura 1).

Figura 1 – Observatórios tecto de correr MPC938 – 1º plano, do C14, 2º plano, do LX200 10”.

Com a experiência obtida nesta manutenção, idealizei o novo observatório tecto de correr para o C14, inteiramente feito com este material. O local escolhido fica uns 10 m a oeste do antigo observatório, numa base inicialmente construída para suporte de uma piscina insuflável. Para este novo observatório optei por painéis com 5 cm de espessura, uma vez que os painéis têm a função estrutural, para além da função de isolamento térmico. A massa destes painéis é da ordem de 10 kg/m^2, o que para o meu projecto de aproximadamente de 2 × 2 m^2, implicaria uma massa de 40 kg para o tecto, com o problema a resolver de calafetar muito bem a junção central entre os dois painéis. Optei por encomendar um tecto em fibra de vidro com as dimensões adequadas (figura 2). Foi mais caro, mas tem apenas uns 20 kg e como é uma tampa com abas, o problema da estanquicidade ficou resolvido. A fibra de vidro não tem a rigidez dos painéis. Apesar da tampa ter uma estrutura interna, flecte um pouco e acumula alguma água da chuva. Não é grave, é questão de verificar e limpar antes de abrir o tecto.

Figura 2 – Fases da construção; tampa e prumos verticais (esquerda), painéis instalados - sul, este e norte, este último já com a “porta cortada” (direita). Verão de 2018.

A primeira operação efectuada foi a instalação da montagem equatorial de garfo do C14, numa posição e alinhamento quase final, (encontrasse coberta nas imagens da figura 2). Esta montagem tem uma massa da ordem dos 100 kg. Após marcação, os prumos verticais (cantoneiras em L) com a altura dos painéis *sandwich* foram aparafusados ao chão. Devido à espessura dos painéis, a distância entre estes prumos (largura das paredes) e de 2,0 m nas faces sul e norte e de 2,1 m nas faces este e oeste. Os painéis encaixam perfeitamente entre os prumos e foram rebitados nestes, sendo também presos e aparafusados ao chão a meio. A altura da parede norte é de 1,90 m. As outras paredes têm a mesma altura, mas com uma aba dobrável a 1,60 m. A sul dobra para fora e a este e oeste, dobram para dentro. Esta funcionalidade permite apontar o C14 quase até ao horizonte, pois está ao nível do eixo de declinação da montagem. As abas este e oeste só podem ser basculadas com o tecto praticamente todo aberto, pois este roda/desliza sobre estas paredes, para norte, (figura 3).

Figura 3 – Fases da construção; vista de SW (esquerda), vista de NW (direita). Verão de 2018.

A tampa tem apenas duas rodas de cada lado e desliza sobre as paredes este e oeste, ao longo de calhas instaladas no lado norte, sobre a porta de entrada. Essas calhas em ferro estão habitualmente tapadas por duas calhas de pvc presas por fitas velcro, que é necessário retirar para abrir a tampa do observatório. A energia eléctrica em via subterrânea (devidamente entubada e isolada) ascende ao longo de um dos pilares de madeira, de apoio das calhas, e entra a nível superior no observatório, figura 4. A parte cortada do painel para a abertura da porta serviu para a construção da mesma.

O montante total despendido nos materiais foi inferior, mas da ordem dos 1.000 Euros.

Actualmente o equipamento instalado neste novo e operacional tecto de correr é o referido C14 na sua montagem equatorial original de garfo, com uma motorização *Bayer Retrofit*. A configuração óptica actual é F/5.4 com recurso a um redutor *Giant Easy Guider* (Lumicon). As imagens digitais são registadas com câmaras SBIG (modelos ST7 e/ou ST10), guiadas com um AO7. A auxiliar a pontaria, feita manualmente com recurso a um NGC Sky Vector (círculos digitais da Lumicon), tenho um refractor SkyWatcher de 120 mm de abertura F/5 com uma antiga MX916 (StarLight Xpress), figura 5. O equipamento de ambos os observatórios é usado e está optimizado para a realização de fotometria e astrometria de asteróides, tendo a designação MPC 938 Linhaceira, desde o ano 2000.

Figura 4 – Fases da construção; vista de N, suporte das calhas (esquerda), detalhe das calhas e sua protecção, instalação eléctrica exterior (direita). 2018.

Figura 5 – Observatório e equipamento; tampa aberta (sup.esq.), C14, SW120 e câmaras (sup.dir e inf. esq), base da montagem e para-luz aquecido (inf.dir.). 2020.

OBSERVATÓRIO DE TECTO DE CORRER

Pedro RÉ
http://pedroreastrophotography.com/

Os observatórios de amadores são habitualmente de quatro tipos distintos: (i) cúpulas; (ii) tectos de correr; (iii) abrigos de correr e (iv) janelas em sótãos ou águas furtadas[1].

O primeiro observatório que construí foi do tipo “tecto de correr”. Actualmente com mais de 40 anos de utilização intensa, continua em perfeitas condições. Trata-se de um abrigo muito fácil de realizar e que permite a instalação de mais de um instrumento de observação que podem ser usados em simultâneo[2] (Figura 1).

Em 2001 terminei a construção de um segundo observatório, uma cúpula instalada próxima do observatório de “tecto de correr”. O segundo observatório foi idealizado com outra finalidade, a observação do sistema solar. Actualmente abriga uma montagem Takahashi EM400 e diversos OTAs que utilizo regularmente para a observação do Sol e da Lua[3] (Figura 2).

Em 2001 foi construída uma plataforma em cimento com 2x2 m (Figura 3) que serviu de base à instalação de um terceiro observatório de tecto de correr.

O terceiro observatório foi construído recentemente (2020) recorrendo a painéis metálicos com isolamento térmico (Poliestireno Extrudido XPS | *Wallmate, Roofmate*) [4].

As paredes do observatório têm uma dimensão de 2X1,8m m e o telhado (tecto de correr) é constituído por duas placas de *Wallmate* totalmente estanque e com uma inclinação de alguns graus. O telhado corre sobre quatro rodízios com rolamentos (Figura 4, 5 e 6).

O observatório abriga uma montagem Paramount ME (Figura 7) que pode ser usada em modo remoto. A montagem será sobretudo usada para obter imagens do céu profundo e do sistema solar (Sol, Lua e planetas). A Paramount ME será controlada recorrendo ao auxílio do software dedicado SKY X [5] (Figura 9).

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[1] Alguns astrónomos amadores instalam ainda pilares fixos em que os instrumentos de observação podem ser montados rapidamente e de um modo semipermanente. Ré, P. (2001). Construção de um pilar fixo para a instalação de telescópios. Astronomia de Amadores, revista da Associação Portuguesa de Astrónomos Amadores, nº 12 (Outubro/Dezembro 2001). Pdf file (103kB) **PDF**

[2] Ré, P. (2000). Como construir um observatório de "tecto de correr". Astronomia de Amadores, revista da Associação Portuguesa de Astrónomos Amadores, nº 7 (Julho/Setembro 2000) **PDF**

[3] Ré, P. (2001). Construção de um segundo observatório. Astronomia de Amadores, revista da Associação Portuguesa de Astrónomos Amadores, nº 12 (Outubro/Dezembro 2001) **PDF**. A cúpula foi construída por um astrónomo amador com uma experiência acumulada de mais de 25 anos (Marcelo Jorge Pereira). Tem cerca de 2m de diâmetro e foi construída em ferro forjado (estrutura) e zinco (aduelas). Possui duas tampas amovíveis que são retiradas antes das sessões de observação (50 cm úteis de abertura da cúpula).

[4] O poliestireno extrudido é uma espuma rígida de poliestireno semelhante ao poliestireno expandido, mas obtida por um processo de extrusão em contínuo, muito leve e usada principalmente como isolante térmico, pela sua baixa densidade, devido à capacidade de conter as partículas dos gases expansores na sua estrutura de formação.

[5] https://www.bisque.com/product/theskyx-pro/

Figura 1- Observatório de tecto de correr.

Figura 2- Cúpula.

Figura 3 – Plataforma 2x2 m.

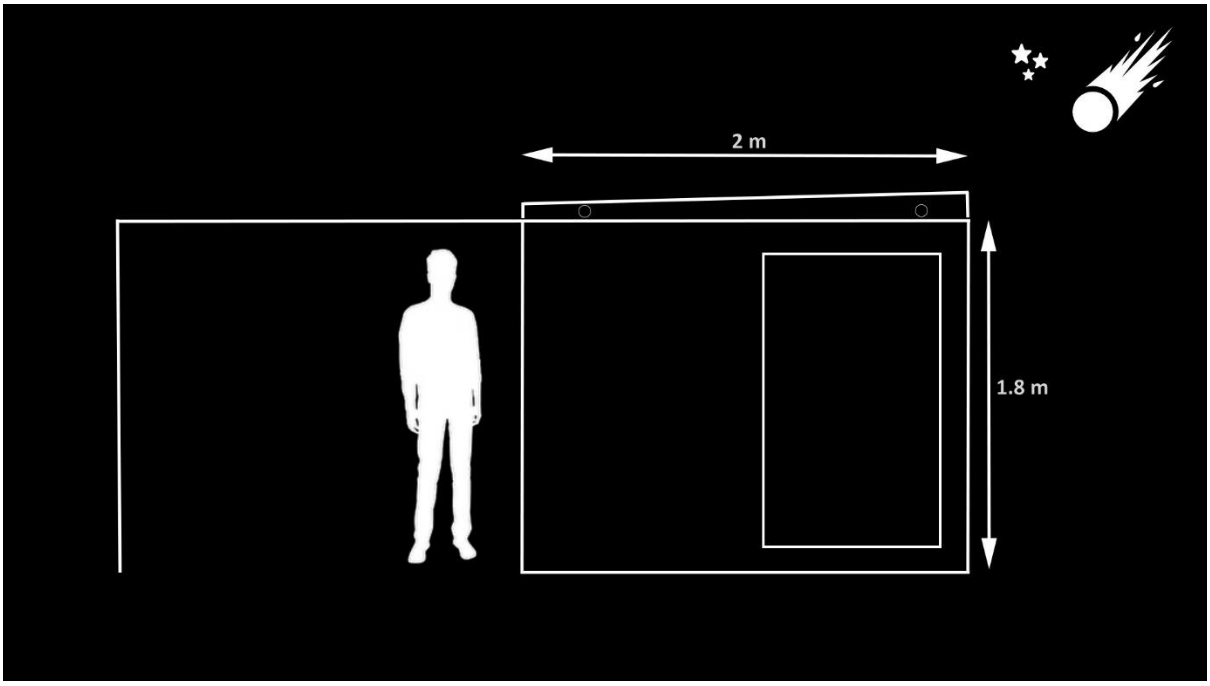

Figura 4 – Observatório de tecto de correr.

Figura 5 – Observatório de tecto de correr (paredes laterais e rodízios).

Figura 6 – Observatório de tecto de correr (instalação das paredes laterais).

Figura 7 – Observatório de tecto de correr (instalação do telhado - *Roofmate*).

Figura 8- Observatório de tecto de correr.

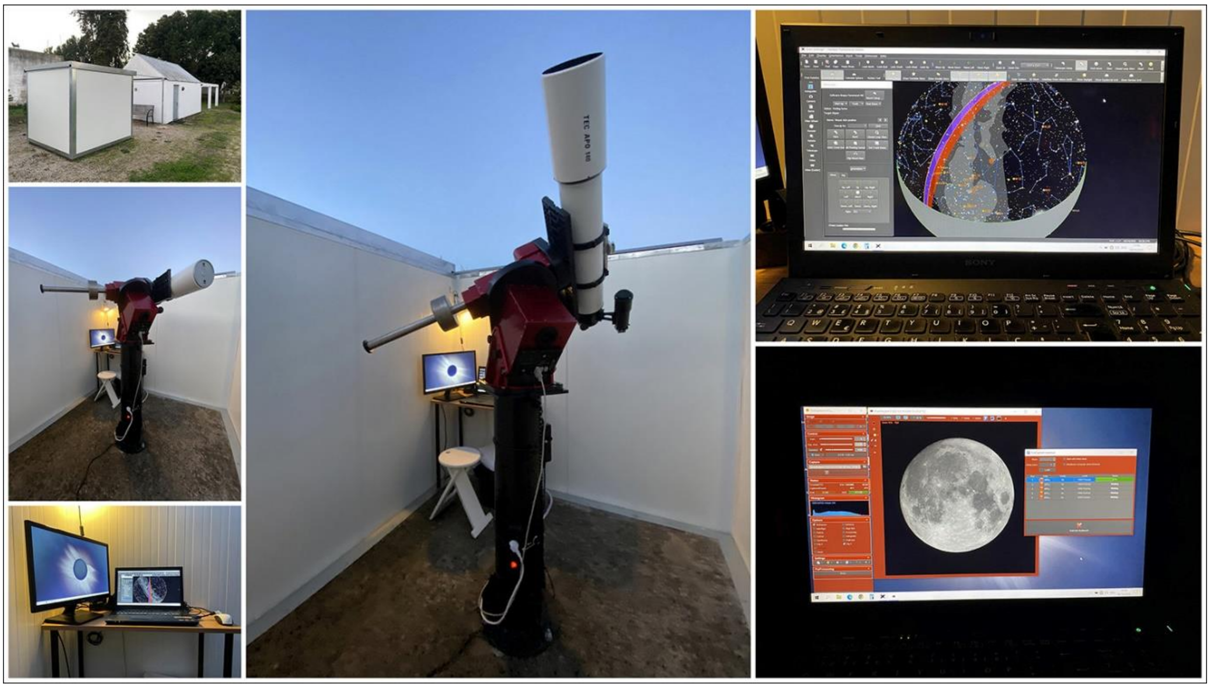

Figura 9- Observatório de tecto de correr (*First Light*) | 20201030.

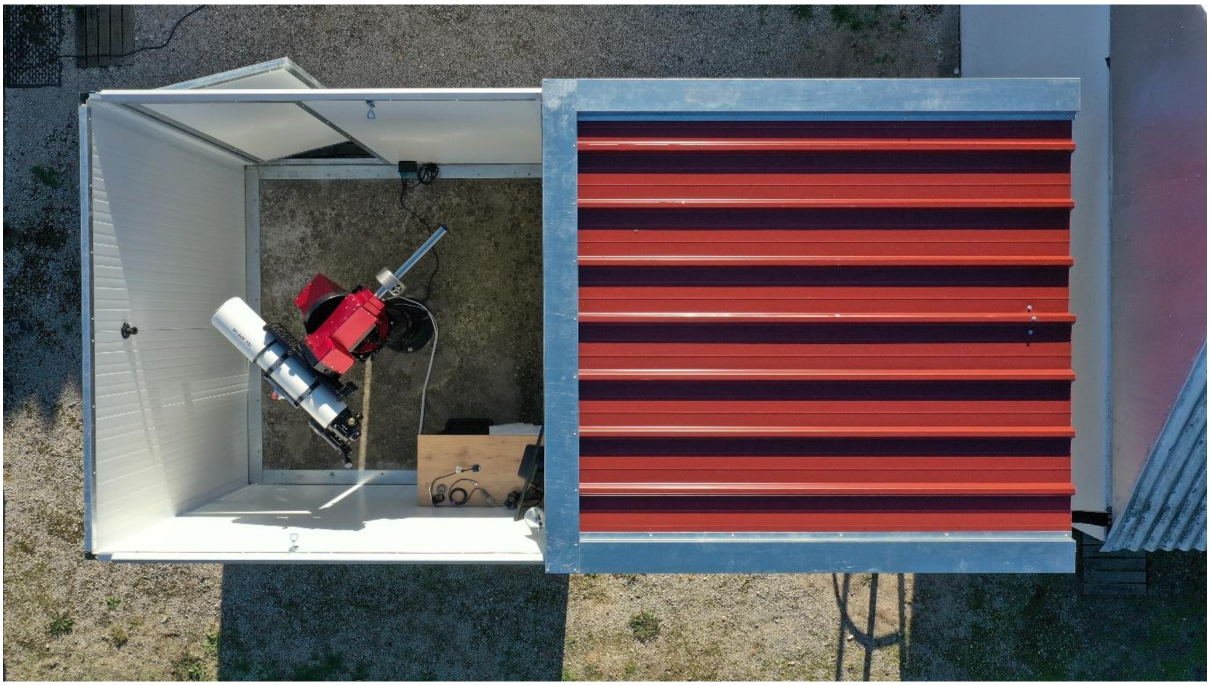

Figura 10 – Observatório de tecto de correr | DJI Mavic 2 Pro.

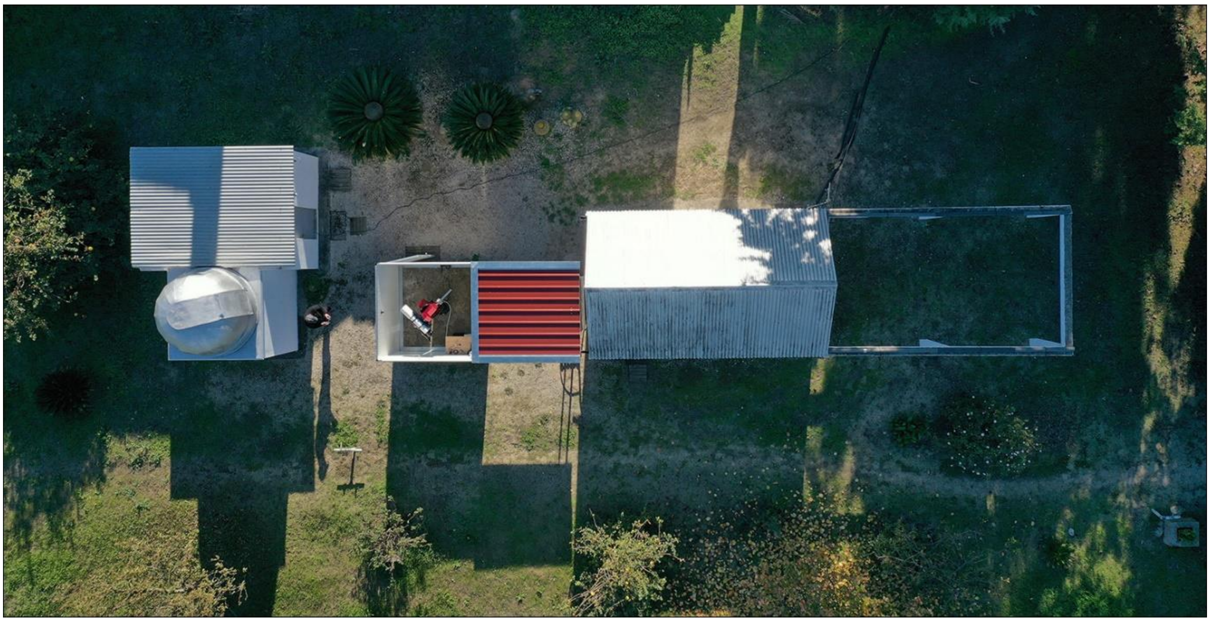

Figura 10 – Observatório de tecto de correr | DJI Mavic 2 Pro.

Youtube Videos:

https://youtu.be/8gNps_2eynI
Roll-off-roof observatory | Pedro RÉ (20201029)

https://youtu.be/GjhKR8dkwQA
Roll-off-roof observatory | Pedro RÉ (20201029)
Kodak PixPro 4K

https://youtu.be/3EGgh9I1_ag
Roll-off-roof observatory | Pedro RÉ (20201029)
Gopro5 4K

https://youtu.be/bCATHJ9_llA
Observatories Pedro RÉ (20201030)
DJI Mavic 2 Pro

https://youtu.be/PtoEQwEE4QY
Observatories Pedro RÉ (20201030)
DJI Mavic 2 Pro

https://youtu.be/lKcpKVdkwSg
Roll-off-roof observatory | Pedro RÉ (20201030)
First Light (20201030)

https://youtu.be/Zh87ttmXJNI
Roll-off-roof observatory | Pedro RÉ (20201031)
Observing the Sun

https://youtu.be/-UVYEk-cNbA
roll-off-roof observatory | Pedro RÉ (20201101)
DJI Mavic 2 Pro - asteroid

https://youtu.be/66ZkRZBbZ0s
roll-off-roof observatory | Pedro RÉ (20201101)
DJI Mavic 2 Pro

https://youtu.be/Vs1d0wpFmRI
roll-off-roof observatory | Pedro RÉ (20201101)
DJI Mavic 2 Pro

ANTONÍN BEČVÁŘ'S ATLASES

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Antonín Bečvář (1901-1965) was a Czech astronomer well known for his excellent Star Atlases. A. Bečvář was born in Stará Bolerlav in 1901 and died in the same town in 1965 (former Czechoslovakia).

At a young age, Bečvář suffered from croup and scarlet fever that caused a marked curvature of his spine. After graduation in 1921 he studied astronomy and meteorology at Charles University in Prague. Doctoral studies (Natural Sciences) were only finished in 1935 due to his health problems.

Since 1937, he worked in Slovakia as a climatologist of the State Health Resort at Strbske Pleso. He was also the founder of the Astronomical Observatory at Skalnaté Pleso[6] and became its first director from 1943 to 1950 (Figure 1).

His most significant contributions are four large astronomical atlases: The **Atlas Coeli Skalnate Pleso** (1948) with a catalogue (1951)[7]; the **Atlas Eclipticalis** (1958); the **Atlas Borealis** (1962) and the **Atlas Australis** (1964). These atlases represented the state of the art in his time. They were reissued abroad and became indispensable for night sky observers all over the world (amateur and professional).

In 1970 the International Astronomical Union (IAU) named after him one of the craters of the Moon and the asteroid number 4567, which was discovered at Klet, also bears his name.

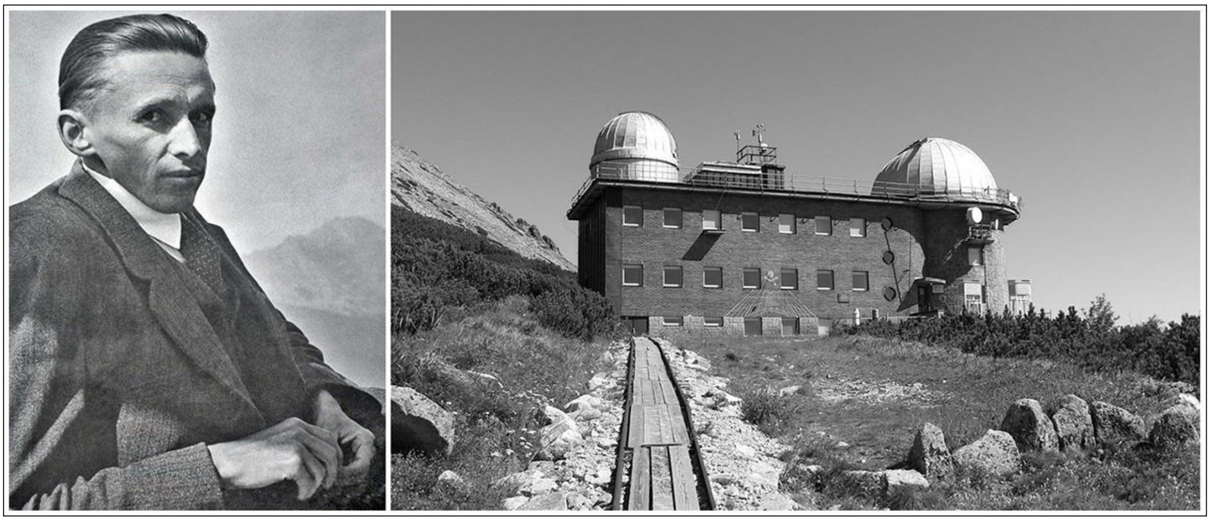

Figure 1- Antonín Bečvář and the Skalnaté Pleso Observatory.

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[6] The Skalnaté Pleso Observatory is an astronomical and meteorological observatory in the Tatra Mountains of Slovakia. It is located at an altitude of 1786 metres on the south-eastern slopes of Lomnický štít near Tatranská Lomnica. The observatory is named after a nearby mountain lake.

[7] The compilation of the *Atlas Coeli Skalnate Pleso* (1951), published by Sky Publishing Corporation as the *Skalnate Pleso Atlas of the Heavens* was the state-of-the-art atlas of its kind until Wil Tirion's "Sky Atlas 2000.0" in 1981.

The ***Skalnaté Pleso Atlas of the Heavens*** (*Atlas Coeli Skalnaté Pleso 1950.0*) is a set of 16 celestial charts covering the entire sky[8] (Figure 2 to 5). The first version of this Atlas was published by the Czechoslovak Astronomical Society in 1948. The Sky Publishing Corporation published a new version in 1949 after acquiring the copywrite.

This Atlas include all stars brighter that magnitude 7.5[9] and all non-stellar objects visible with an 8-inch telescope (Nebulae, Star-Clusters and Galaxies). The coordinate system in referred to 1950 and the scale is 1 degree = 0.75 mm. Stellar magnitudes are shown as circles with graded sizes. Double and multiples stars are identified. Variable stars are identified as well. 243 Clusters (including all globular clusters) many Nebulae and Planetary Nebulae and 1130 Galaxies are also clearly identified. The outline of bright and dark Nebulae is shown, and their relative size is indicated. The Milky Way and prominent obscuring clouds within it are indicated by isophotic lines. Constellation boundaries, the celestial equator, ecliptic, and major radio sources are also shown. After publication of the *Atlas Coeli*, a supplement was produced, the *Atlas Coeli II - Katalog 1950.0*. This *Catalogue* contains data and descriptions of approximately 12000 objects plotted in the *Atlas*. All stars to magnitude 6.25 are included as well as many non-stellar objects.

Figure 2- The Skalnaté Pleso Atlas of the Heavens (*Atlas Coeli Skalnaté Pleso 1950.0*) and the Wil Tirion's "Sky Atlas 2000.0". Author’s personal copies.

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[8] All charts were hand-drawn by Antonín Bečvář.

[9] All stars brighter than 7.75 magnitude are included, for a total of 32,571.

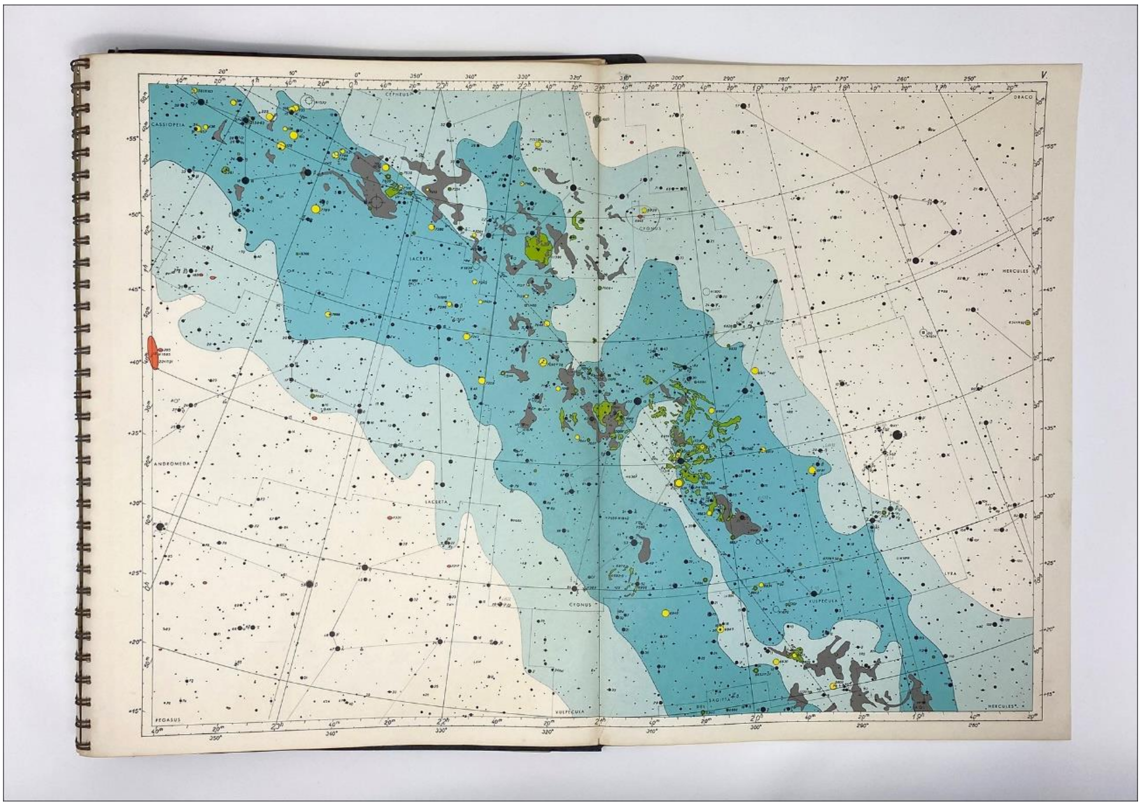


Figure 3- The Skalnaté Pleso Atlas of the Heavens (*Atlas Coeli Skalnaté Pleso 1950.0*).

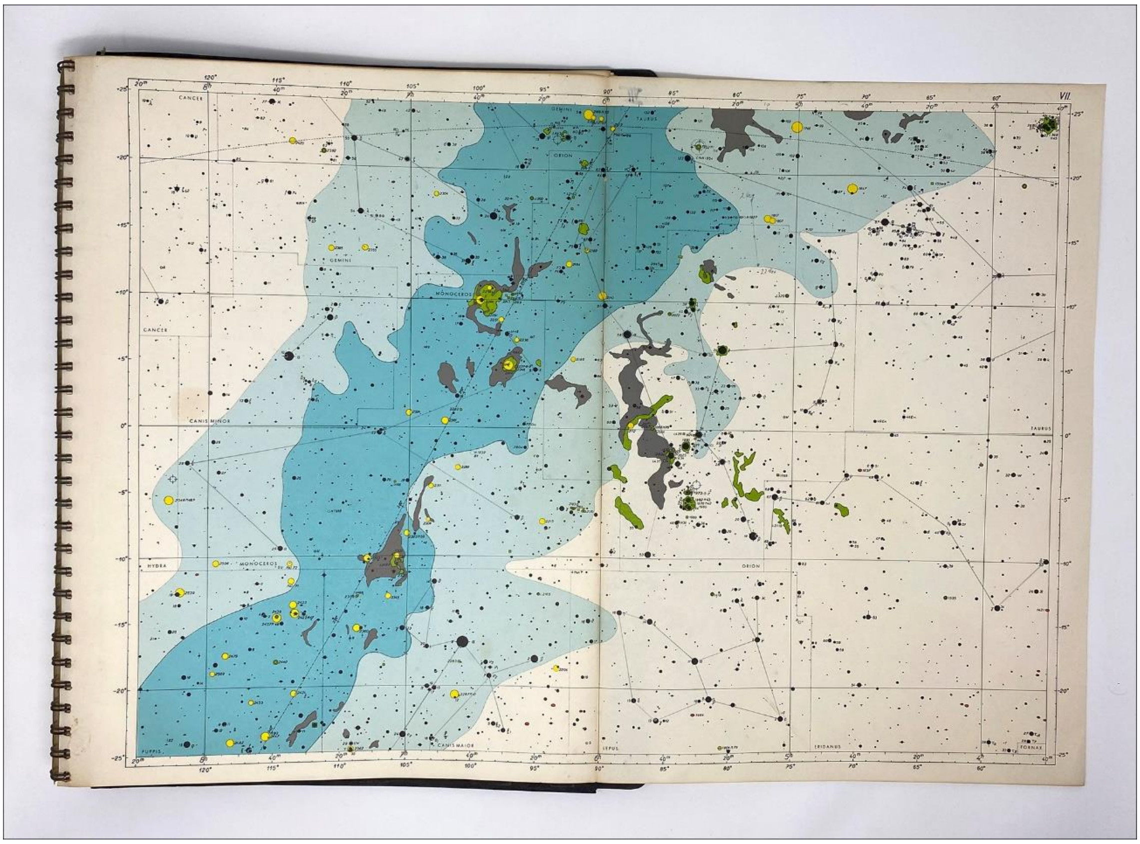


Figure 4- The Skalnaté Pleso Atlas of the Heavens (*Atlas Coeli Skalnaté Pleso 1950.0*).

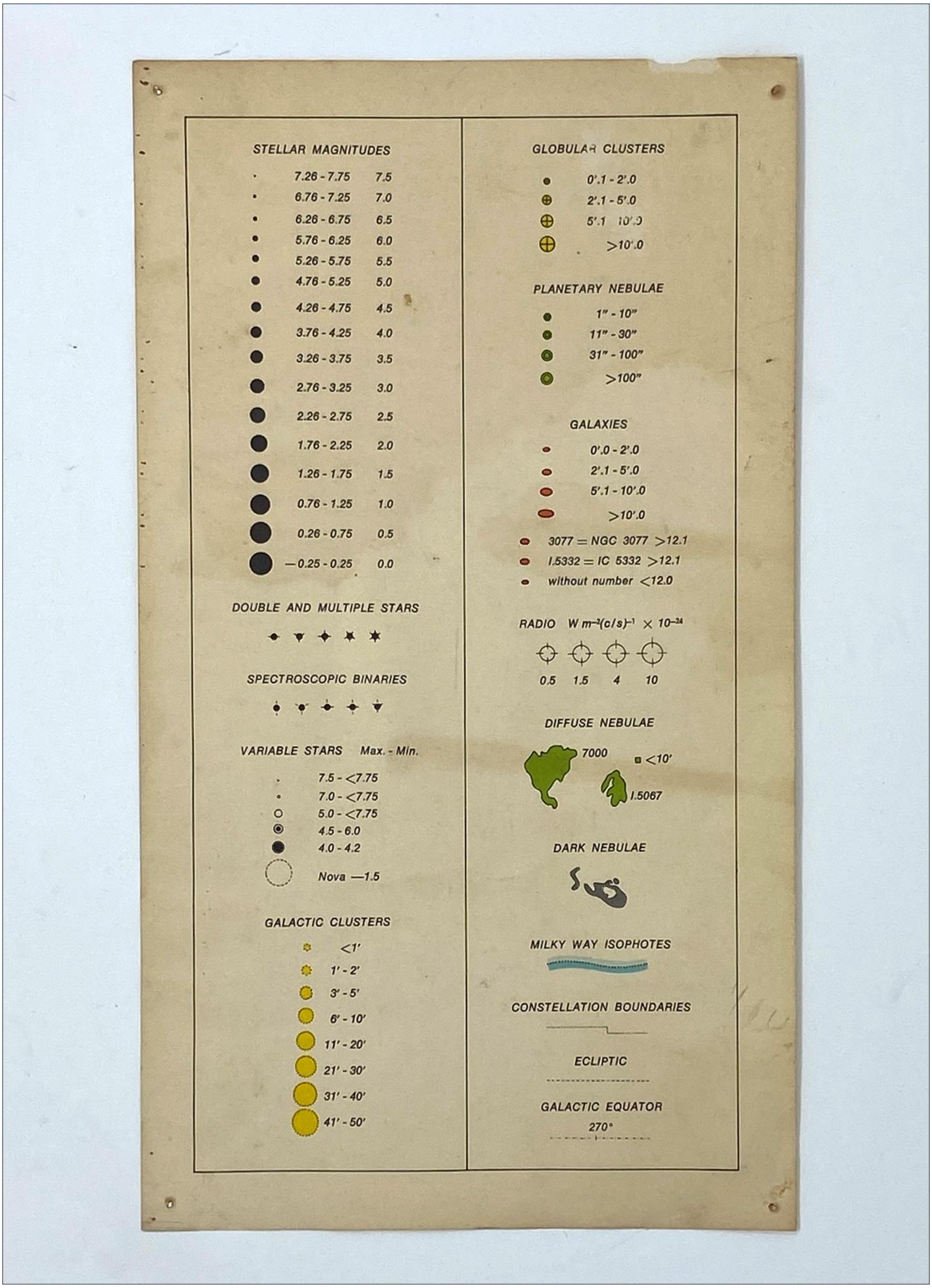


Figure 5- The Skalnaté Pleso Atlas of the Heavens (*Atlas Coeli Skalnaté Pleso 1950.0*).

After his retirement Bečvář worked on three celestial atlases with a different scale 1 degree = 20 cm: **Atlas Ecliptalis** (the celestial region between -30 and +30° of declination on 32 charts); **Atlas Borealis** (the celestial region northwards from declination of +30° on 24 charts) and **Atlas Australis** (the celestial region southwards from declination of -30° on 24 charts). These Atlases are very different from the *Atlas Coelli*. Stars are plotted considering their precise position and proper motions. Non-stellar objects are not plotted, and a six-colour press was used to distinguish six basic spectral classes of the stars. The three atlases were also published by the Sky Publishing Corporation (Figures 6 to 9).

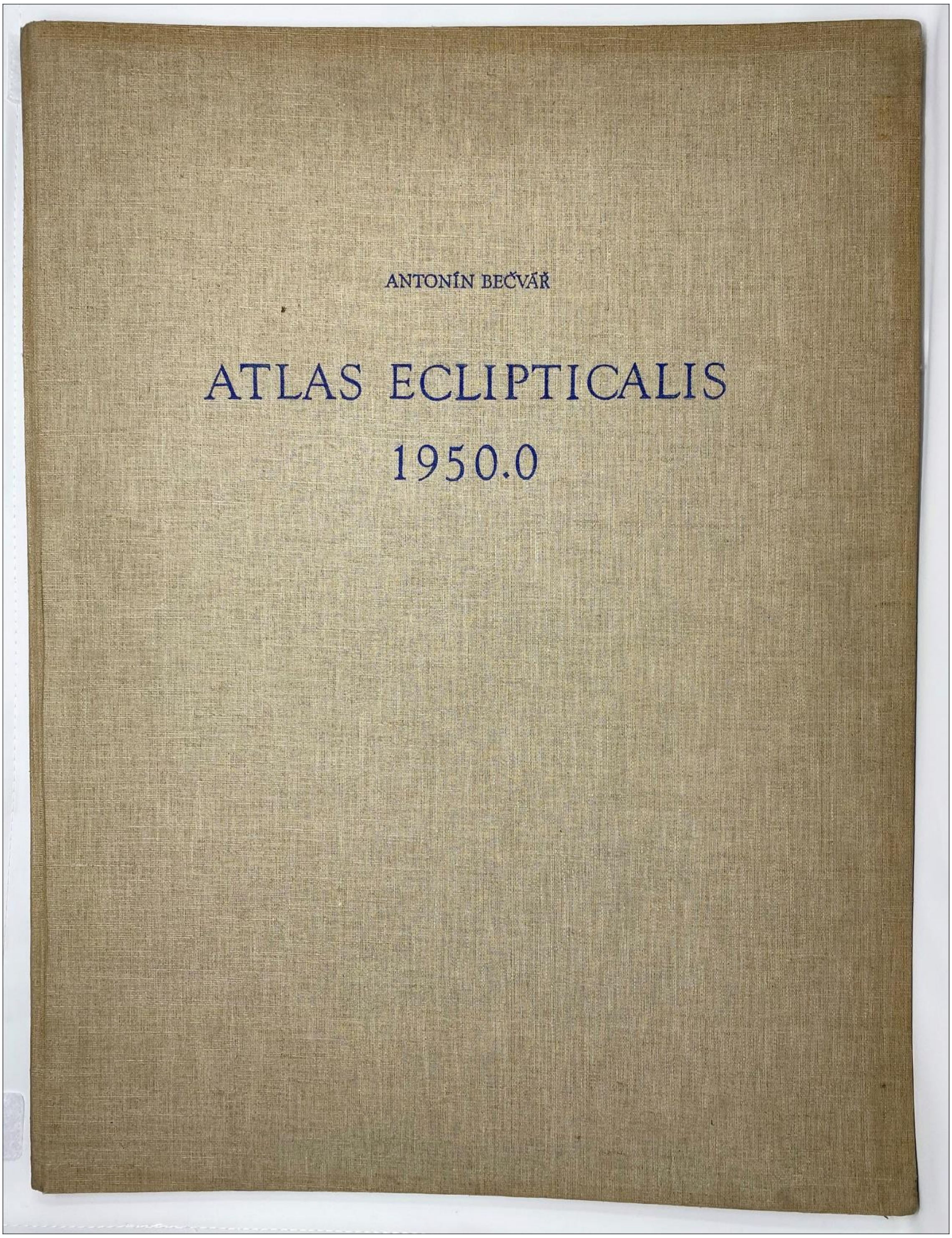


Figure 6- Atlas Eclipticalis. Author’s personal copy.

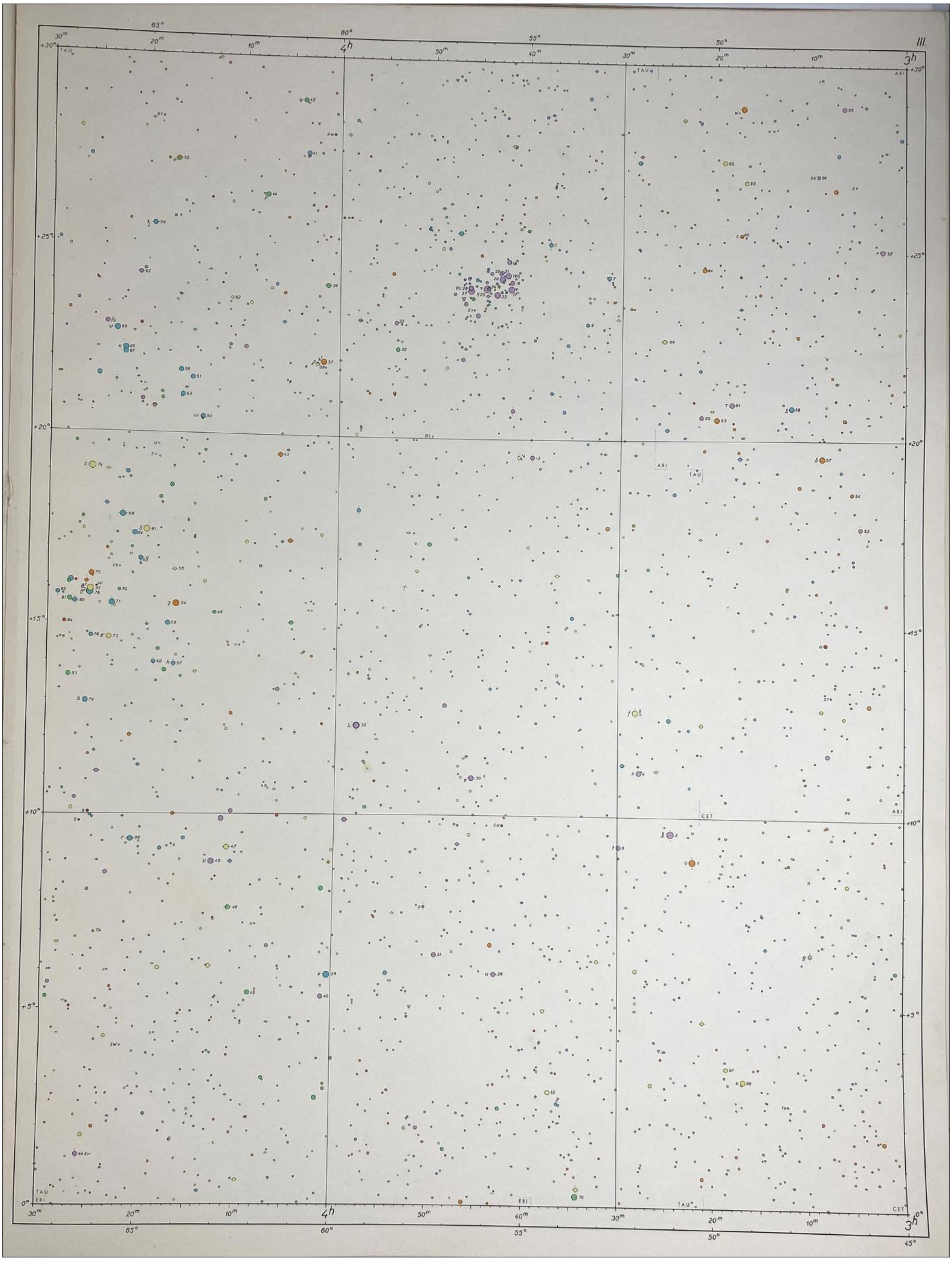


Figure 7- Atlas Eclipticalis. Author’s personal copy.

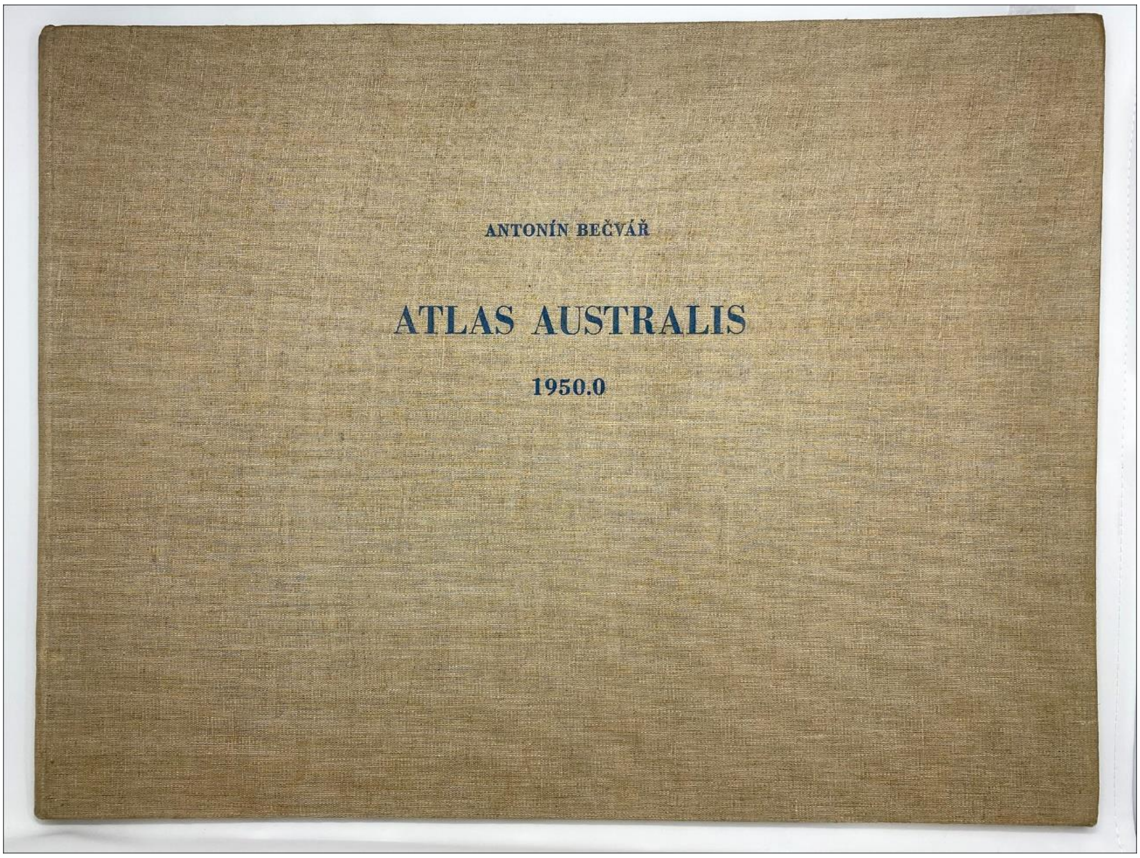


Figure 8- Atlas Australis. Author’s personal copy.

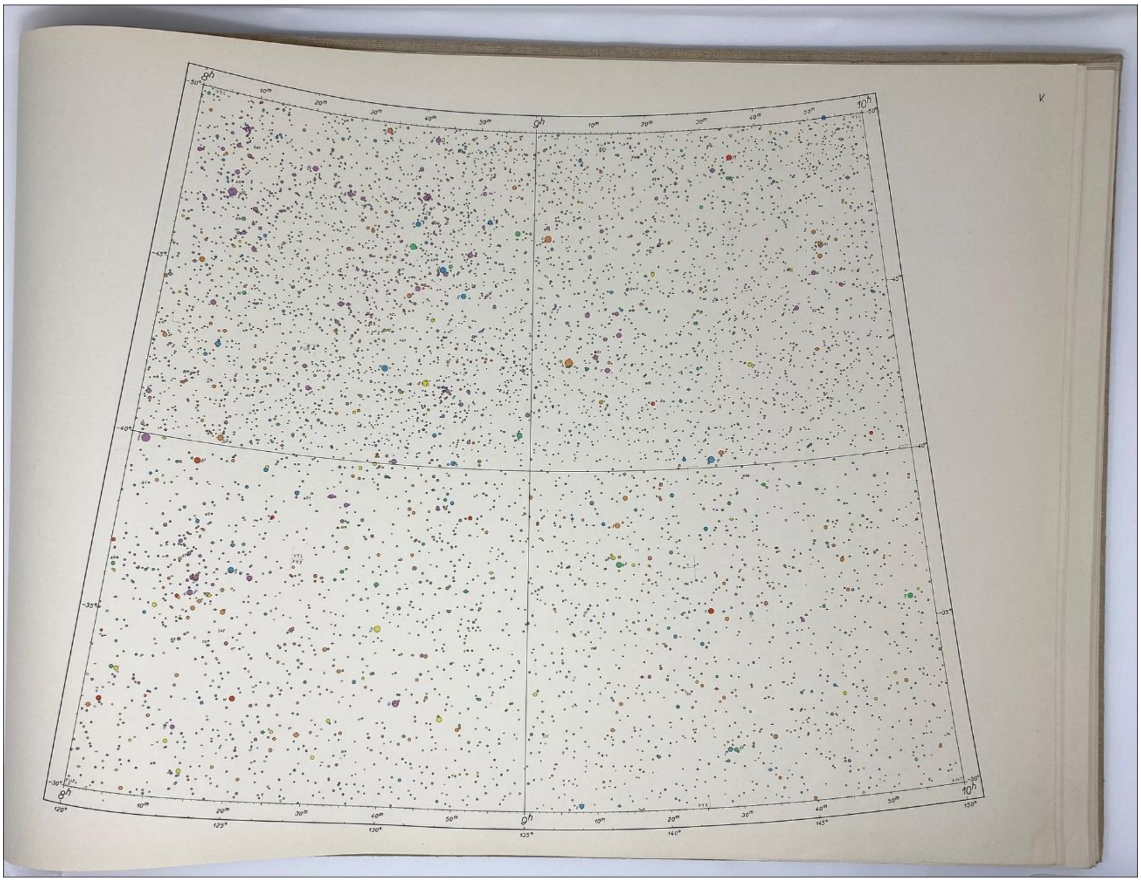


Figure 9- Atlas Australis. Author’s personal copy.

EUGENE VON GOTHARD (1857-1909), THE FIRST AMATEUR ASTROPHOTOGRAPHER

PEDRO RÉ
http://pedroreastrophotography.com/

Eugene (Jenö) Von Gothard was born on 31 May 1857 in Herény, Hungary. After receiving a degree in mechanical engineering, Gothard founded the Herény Astrophysical Observatory in 1881 when he was 24 years old (Figure 1).

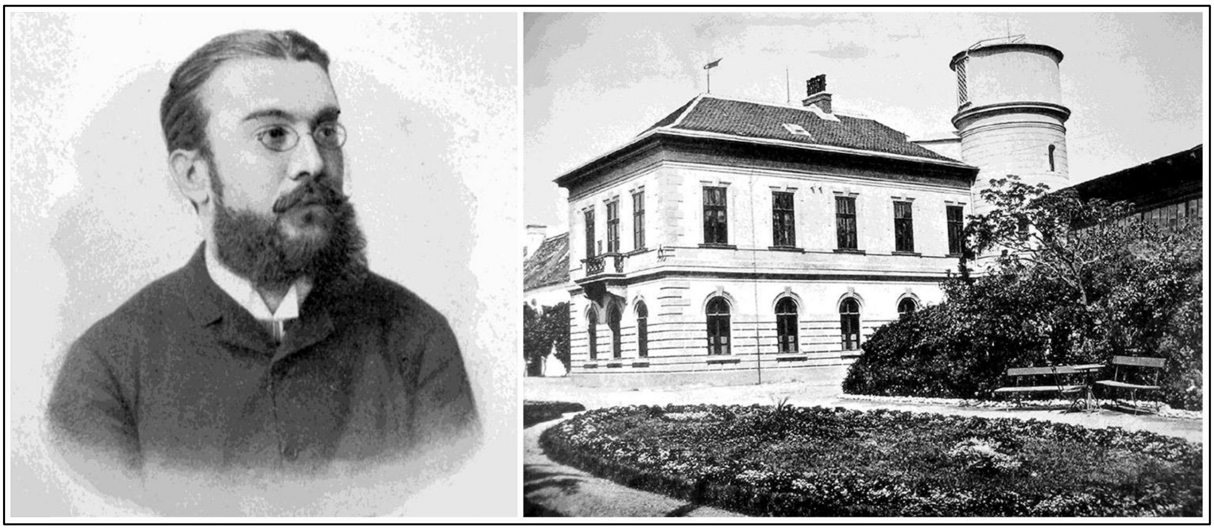


Figure 1- Eugene Von Gothard and the Henéry Astrophysical Observatory.

Eugene V. Gothard played an important role in European astronomy at the end of the nineteenth century. His pioneering astrophotographs were known worldwide. The scientific inheritance of Gothard is preserved by the Gothard Astrophysical Observatory at the Loránd Eötvös University. A valuable part of this material is the astronomical plate collection of 455 plates obtained from 1882 to 1900, containing unique images of comets, star clusters, nebulae, galaxies, and stellar spectra. Eugene recorded the central star of the Ring Nebula, Messier 57, for the first time in September 1, 1886, and in doing so became the first amateur astrophotographer.

After completing his studies in 1879 Eugene studied abroad before returning to his estate at Herény, with the intention of setting up his own Physics Laboratory. Eugene soon changed his initial plans, mainly because of his interest in Astronomy and because of the influence of his friend and astronomer, Nicolaus Von Konkoly (1842-1916). Jenö decided instead to add an Astronomical observatory to his Physics Laboratory and the first observations were made on the 20th of October 1881 at the newly inaugurated Herény Astrophysical Observatory[10].

In 1882 Jenö recorded the total eclipse of May 17, 1882 (partial in Hungary) (Figure 2) and he was also the first to detect the central star of M57 in the autumn of 1886 (Figure 3).

---

[10] Until 1883, Gothard was assisted in his astronomical observations by his brother Sándor (1859-1939), while their youngest brother István (1869-1948) took part in the recording of meteorological data at the weather station located in the garden of the observatory. At the time of the observatory foundation, Jenö's aim was spectroscopic investigation of emission line stars and comets, while Sándor observed planets and the Sun.

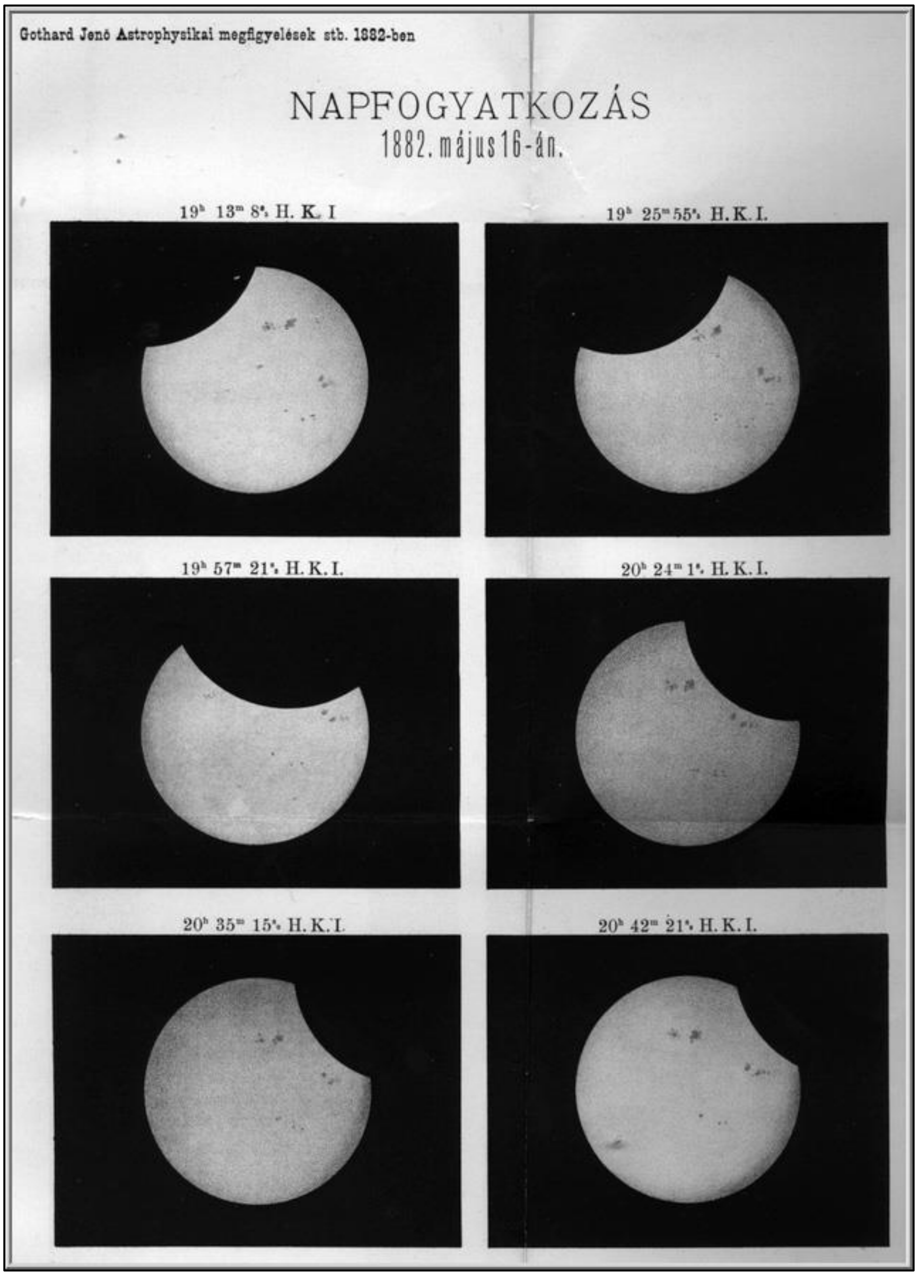


Figure 2- Gothard's original plates of the total solar eclipse of May17, 1882, visible partial from Hungary.

The main building of the observatory had a physical, chemical, and photographic laboratories and a mechanical workshop as well. The observatory had also facilities for meteorological and earth magnetism observations.

The observatory's main instrument was a Newton reflector with a mirror of 254 mm (Figure 4), manufactured in 1874 by the Browning company, London and purchased by Miklós Konkoly Thege in 1881. Jenö Gothard gradually added new and modern tools for astrophotography and spectroscopy. His degree in mechanical engineering from the Polytechnics Hochschule in Vienna proved to be a good basis for his excellent instrument construction work. He designed and, together with his technician, created the instruments and auxiliary equipment for his astrophysical research in the observatory's mechanical workshop.

Figure 3- Gothard's original plate recording the central star of the Ring Nebula (M57) for the first time in September 1, 1886.

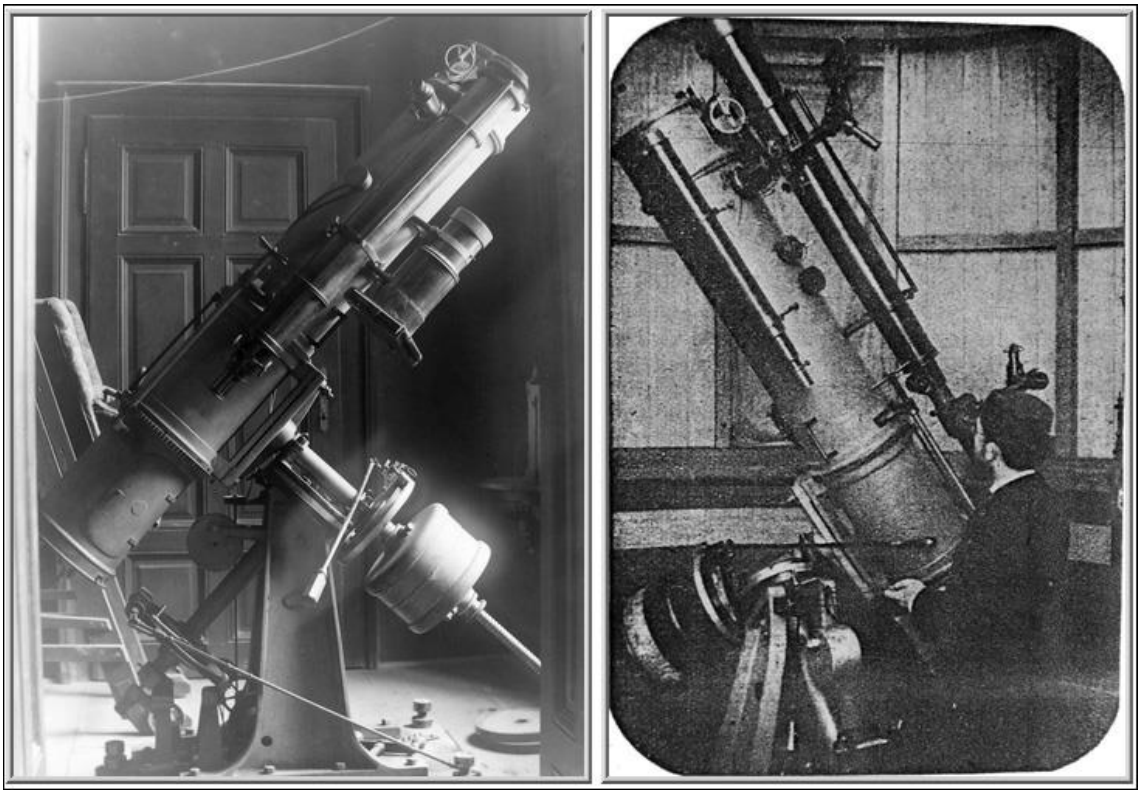


Figure 4- 254 mm Newton reflector, the main instrument of the Gothard's observatory.

At the time of the observatory foundation, Jenö Gothard's aim was the spectroscopic analysis of emission stars and comets.

After 1883, he turned his attention to the examination of the spectrum of the β Lyrae. In his observations he discovered the periodical appearance and disappearance of hydrogen and helium lines. This discovery did not get any attention, as there was no sufficient astronomical background for the interpretation of the phenomenon, which gained significance later. In the scientific community of the turn of the century Gothard attracted attention to his spectroscopic examinations of comets. He photographed a comet invisible visually for the first time (Barnard-Hartwig Comet, 1886).

From 1885 onwards, Jenö almost abandoned visual observations and turned to the new technologies of the age, spectrography and astrophotography (Figure 5). In 1885, he recorded a supernova in the Andromeda Galaxy, Messier 31.

From 1886 onwards he was completely engaged in spectrophotometric examination of clusters, comets, and nebulae. Until 1891, during the first 10 years after foundation of the observatory, Gothard worked successfully in the field of spectroscopy and astrophotography.

In 1892, while studying the spectrum of Novae Aurigae, he revealed a principal connection between nova’s and planetary nebulae. Gothard proved that "... *the spectrum of the nova is identical to the spectrum of planetary nebulae*". This discovery was the most outstanding result of his scientific work. His result is regarded by experts worldwide as one of the predecessors of theories on the later stages of stellar evolution.

Eugene Von Gothard was recognized for his research worldwide. In 1883, he was accepted as a member of the Royal Astronomical Society, in 1884 member of the association of leading European astronomers, the German Astronomische Gesellschaft and in 1890 a corresponding member of the Hungarian Academy of Sciences.

In 1894/95 the first Hungarian hydroelectric power plant was built in Ikervár. The Vasvár County Electric Works Inc. was founded with Jenő Gothard as its first technological manager. Besides being engaged in management and organization, he also designed and patented several industrial devices. New tasks and technological challenges reduced the intensity of his astronomical activities.

Only after many years could he return to astronomy for a short period, starting in 1901. With the same precision as earlier, he took a high-resolution spectrum of the "new star", Nova Persei in Perseus.

In the final period of his rich and productive life, Jenő Gothard travelled a lot. He toured Egypt, pursuing his scientific and archaeological passions.

His observations and scientific results appeared in a special volume published (in German) by the observatory, entitled "*Publikationen des Astrophysikalischen Observatoriums zu Herény In Ungarn*" (Figure 6). Articles were issued about his life's work in the series of the Hungarian Academy of Sciences, entitled "*Értekezések a Matematikai Tudományok Köréből*". The series entitled “*Meteorological Observations at the Herény Observatory*" was published from 1890 to 1918.

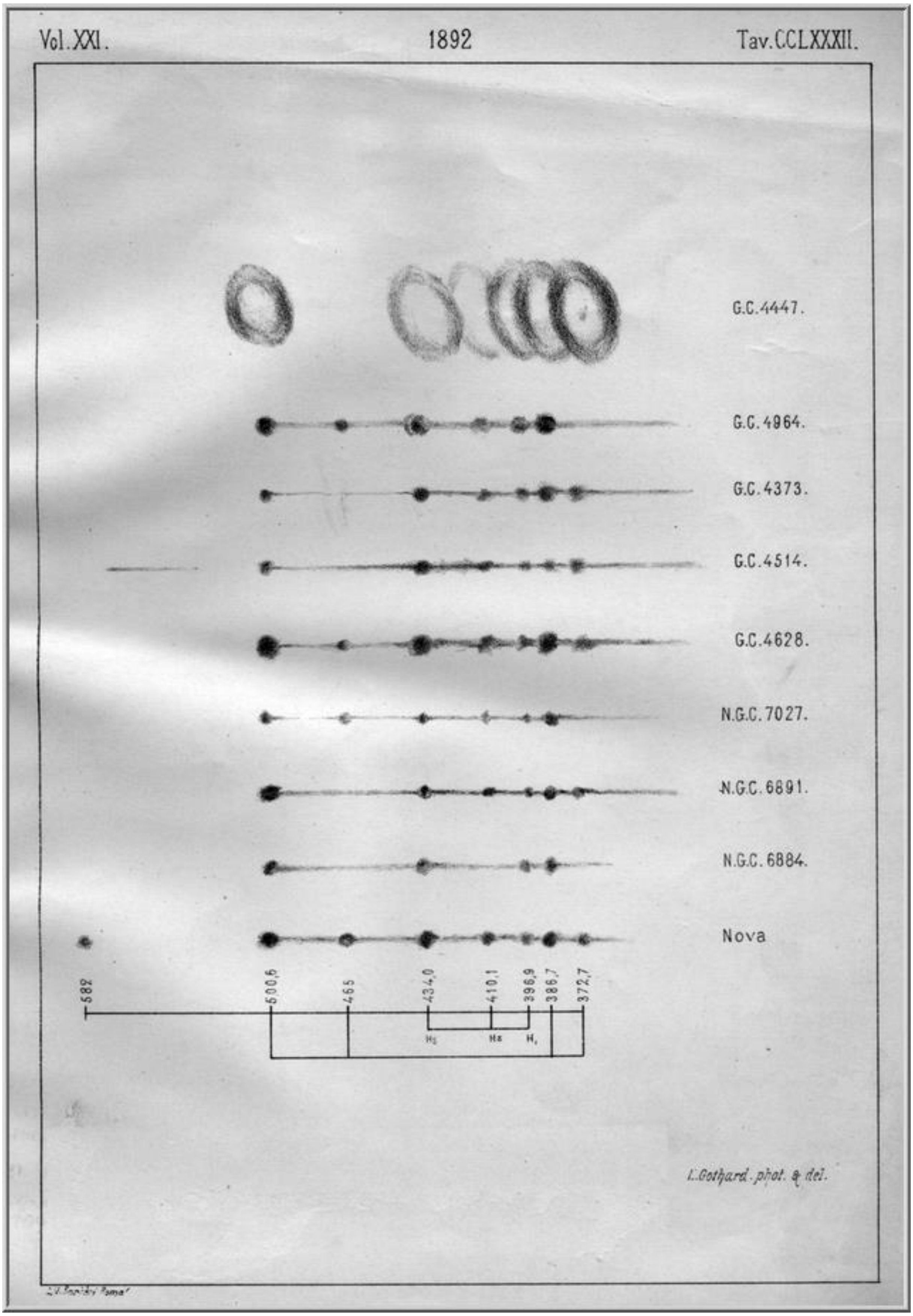
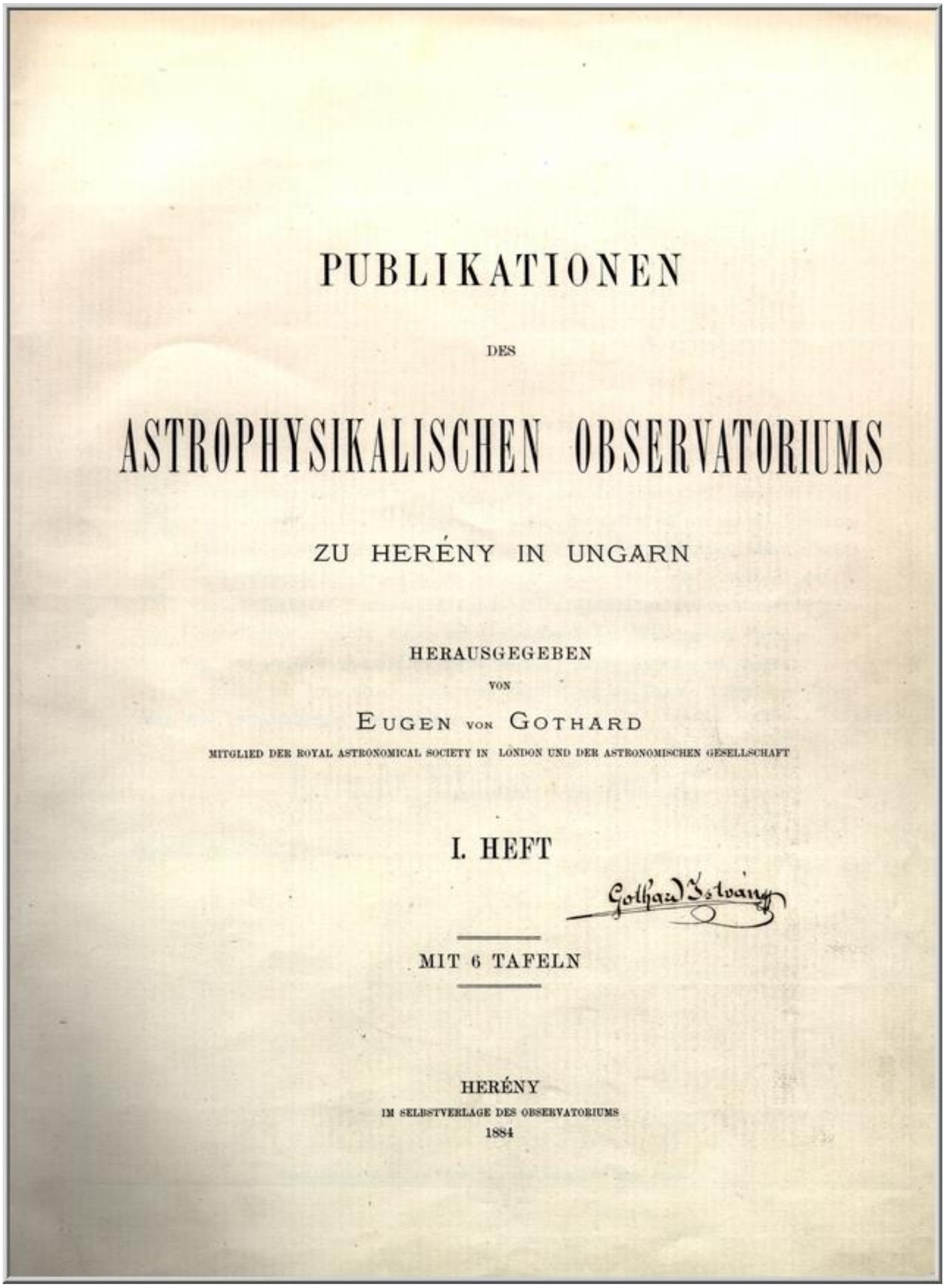


Figure 5- Spectra of several planetary nebulae and Nova Aurigae.



PUBLIKATIONEN

DES

ASTROPHYSIKALISCHEN OBSERVATORIUMS

ZU HERÉNY IN UNGARN

HERAUSGEGEBEN

VON

EUGEN VON GOTHARD

MITGLIED DER ROYAL ASTRONOMICAL SOCIETY IN LONDON UND DER ASTRONOMISCHEN GESELLSCHAFT

I. HEFT

Gothard István

MIT 6 TAFELN

HERÉNY
IM SELBSTVERLAGE DES OBSERVATORIUMS
1884

Figure 6- Special volume published (in German) by the observatory, entitled "Publikationen des Astrophysikalischen Observatoriums zu Herény In Ungarn”.

References:

Hughes. S. (2013). *Catchers of the Light*. ArtDeCiel Publishing: 1612 pages.

Vincze, J.I and I. Jankovics (2012). In memory of Eugene (Jenö) Von Gothard: a pioneering nineteenth century hungarian astrophysicist. *Journal of Astronomical History and Heritage*, 15 (2): 105-114.

QUESTAR 3.5" DUPLEX (1976)

PEDRO RÉ
http://pedroreastrophotography.com/

History of Questar

Questar Corporation was founded in 1950 by the inventor of the 3.5” telescope, Lawrence Braymer. L. Braymer lived in Solebury, Bucks County and was an illustrator by trade. His wife, Marguerite Braymer, an advertising executive, was his active partner in the development of the company. Braymer had a passion for fine art and artistic detail and loved astronomy. He designed, applied for and received a patent in 1948 for what is now referred to as “*The Questar, the finest small telescope ever made*”. His design was revolutionary in its compactness, durability and portability.

Questar was on the cutting edge with its unique design and innovative application opportunities. The initial design of the astronomical telescope evolved to encompass the microscope and surveillance lines of optical and scientific instruments.

Over 200 parts comprise the Questar Astronomical Telescope. Every part of each telescope, microscope or surveillance instrument was inspected, tested and assembled to the minute quality tolerances upon which the standard of the industry has been set.

Natural evolution and new technology helped to establish the next generation of instruments: the Questar 7”, Questar Birder and the Questar Field Model. Today Questar is known worldwide and has set the highest standard for optical performance. In the 1960’s, Questar optical systems were introduced for industrial use in many US government projects such as the Gemini space program. First in space, images of the earth taken through a Questar made and continue to make headlines. In 2002, Questar introduced the new Lightweight Titanium 7” and the QMAXTM Solar Spectrometer.

"The Questar is a tool that is appealing to the eye - a work of art and mechanical excellence whose performance and durability tend to keep its owner loyal. Over many years I have come to own and use more than thirty telescopes; at any given time, I may own about five instruments. With my interest in so many areas of astronomy no one or two telescopes can serve all my needs well. As I moved from one telescope to another, I learned their strengths and weaknesses, and I sought improvement. However, while other telescopes have come and gone the one that has outlasted the others, been used the most, and which I envision retaining as long as I am able to move is my Questar”.

A Questar is very easy to transport and set up. It is that component in my logic that supports my "the best telescope is the one that gets used" philosophy. A Questar can be set up from its carrying case, Pole Aligned and tracking on a planet in about three minutes. For extended travel I rarely choose a telescope other than my Questar. Sure, the Questar is not as "good" as my larger superb telescopes in terms of what I can see or image. However, my 7 lb. (3.2 kg) Questar with its compact tracking mount is a tool that does what it does more often, better and quicker than any other similar compact telescope on the market, and it looks better while doing so!"

Martin Cohen, Director of Company Seven

The American made Questar has since 1954 been acclaimed as an elegant and refined practical tool for astronomy: *the Rolls-Royce of compact telescopes*. The fundamental attributes attracting such praise remains the same today as it was: performance, convenience, and reliability. The Questar is among the last of few products in production over the recent decades where no practical or aesthetic aspect has been compromised in order to cut costs. This arguably remains the best balance of essential attributes in the carry-on portable class of telescope (Figure 1).

The Questar telescopes were available in several apertures, each with several configurations, and each configuration with a good selection of options for visual and imaging applications. Questar is a distinguished line admired worldwide since the introduction in May 1954 of their first early production telescopes for their high performance, ease of use, their innovations, and for their uncompromising high quality of workmanship and materials.

Figure 1- Early Production Questar 3 ½ Telescopes: 1954 and 1955.

Questar Models

The **Questar Standard 3 ½”** has for nearly sixty years been regarded as the finest compact personal telescope in the world. The Questar Questar Standard 3 ½” was manufactured to high industrial levels of perfection and durability. They were made to provide more than a lifetime of rewarding service and many Questars from the early 1950's remain in service to this day. It has been for many aspiring astronomers the "Holy Grail" of compact telescopes (Figure 2).

The **Questar Field Model** or **Birder** are basically a Questar 3 ½" Optical Tube Assembly only. These are best suited to those who need the utmost in light weight and compact high magnification performance. Common applications include birding and nature watching. These serve well as a rugged and compact high resolution Ultra-telephoto lens, or in astronomy as a high magnification photo-guide telescope (Figure 3).

The Questar **Duplex Model** is a Questar 3-½" Optical Tube Assembly mounted to the Questar Fork Mount in a manner which allows the easy disjoining of optical tube from the mount. This Questar can be used as either a portable telescope or as an ultra-telephoto lens (as the Field Model) without the need to carry the extra bulk of a fork mount. And yet this arrangement still offers the owner an extremely portable tracking telescope when the tube is "docked" into the fork mount (Figure 4).

Figure 2- Questar 3 ½” Standard telescope.

Figure 3- Questar 3 ½” Field Model or Birder telescopes.

Figure 4- Questar 3 ½” Duplex.

The **Questar 7”** telescope was introduced in 1967, with the first optics set being completed for Questar on 1967 at manufacturing facilities nearby Company Seven in Maryland. These were limited production handcrafted instruments, with production over time averaging about 25 instruments per year (Figure 5).

Figure 5- Questar 7”.

The QUESTAR 12” was introduced in 1976. By the mid 1970's research in laser transmission and reception was increasing the need for larger aperture yet robustly constructed optical systems. Among the markets for these new instruments was Light Detection and Ranging (LIDAR), and missile tracking for film recording of rocket launches. Questar had up to this time offered systems with apertures as large as 7 inches (180mm), but competing products were coming available in 8 to 10 inch and larger apertures. So Questar began work on a larger optical system, settling on 12” (300mm) for production with hopes of marketing this new system for applications involving Geomatics, geography, geology, geomorphology, seismology, remote sensing and atmospheric physics. The instrument seemed to be a natural choice too for astronomical uses by advanced amateurs and schools (Figure 6).

QUESTAR® 12 on the
QUESTAR® MOUNT

© Questar Corporation 1981

The Questar 12, latest addition to the Questar family of fine optical instruments, now has its own Questar-designed mount. A German equatorial-type, it is notable for its 360° continuous tracking in R.A. with precision tracking to better than 4 arc seconds.

The Questar Mount is designed with over-sized components so that it can accommodate any Questar up to 18 inches. The standard mount shown is straightforward in design but can be modified so as to be compatible with more sophisticated tracking devices or other special equipment.

The Questar 12 is a superb instrument for the serious astronomer, for the university astronomy department or the engineer seeking sophisticated tracking and surveillance equipment for which Questar Corporation has a noted reputation.

Observing domes suitable for housing the Questar 12 or larger telescopes are also available at Questar. We can offer the Observa-Dome or the Ash-Dome. Come see one erected on our site here near New Hope.

For literature write to
Questar Corporation

Box C, Dept. 10, New Hope, Pa. 18938 (215) 862-5277

Figure 6- Questar 12”.

The Questar I own is a beautiful 1976 Duplex 3 ½” model (Serial number: 6-CV-DP-6377-B) (Figure 7 and 8).

Specifications:

1. Duplex 3.5" with Cervit Mirror (Zerodur), Broadband and Low-Reflection Coatings
2. Manufactured: 1976 | Returned for full factory service: April 1985
3. Fitted, velvet-lined carrying/storage case with key (leather covered w/door pouches)
4. Eyepiece and Filter Case (laminated wood w/foam lining)
5. Brandon eyepieces; 8mm, 12mm, 16mm, 24mm and 32mm
6. Screw-in front lens cap
7. Three legs for tabletop use
8. Solar filter
9. Synchronous Electric Clock Drive (110v)
10. Power cord for the Synchronous Electric Clock Drive
11. Plain blue dew cap/barrel cover (no star chart or moon map)
12. Factory Instruction Manual
13. Nikon Camera Adaptor/Camera Coupling Set
14. Image Erector (straight-through viewing)
15. Davis & Sanford (now Tiffen) Heavy Duty Factory Tripod

Figure 7 – Questar Duplex 3 ½” model (Serial number: 6-CV-DP-6377-B), 1976.

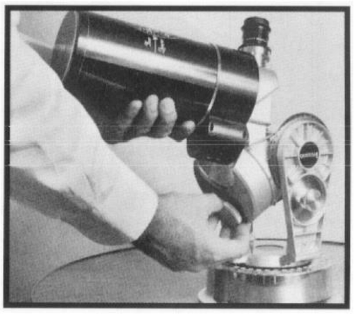
Figure 8 – Questar Duplex 3 ½” model (Serial number: 6-CV-DP-6377-B), 1976.

QUESTAR®
The Optical Innovators

Questar Duplex

3.5" Telescope

Specification Sheet

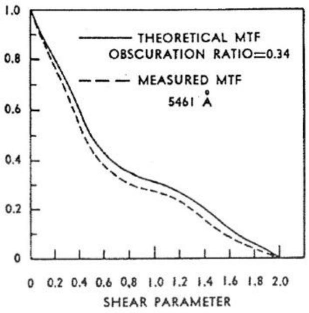


The Questar Duplex is the most versatile Questar instrument because its design permits it to be separated into two parts. The barrel, which is actually the Field Model with moon map and star chart added, can be carried separately in its own case for field trips. When the two parts are assembled, the Duplex has every feature of the fully mounted Questar Standard astronomical telescope. To separate the barrel from the mounting, hold it in one hand, and release the knurled screw under the collar which supports it. The screw attaches to the _-20 hole in the bottom support of the barrel which is used also to connect it to a tripod.

The Duplex includes lens cap, removable optical tube assembly with mounting holes for most tripods, 16mm (80-120X) and 24mm (53-80X) eyepieces, built-in finder (4X & 6X), Barlow lens for eyepiece port, star-diagonal prism, 110 VAC synchronous electric drive. Continuous 360 ° slow motion controls 25:1 with manual override slip clutch on both axis, Declination clamp, setable right ascension and fixed declination setting circles, finder solar filter and carrying case. Velvet lined case has door pouches that hold one eyepiece, 1.5" aperture solar filter, electric cord, powerguide hand control and legs for converting to table-top polar equatorial position. A 1/4-20 mounting hole centrally located on base can be used to attach most tripods. 30-45 ° legs are standard. Special order for other latitudes. Questar barrel has moon map and perpetual star chart; the latter pulls forward to form dew cap. Weight less than 8 lbs., in carrying case 15 lbs. Shipping weight 31 lbs. in specially designed packing and drum. *(Specify voltage and latitude)*

TYPE:	Maksutov Cassegrain Catadioptric. No coma, astigmatism or spherical aberrations.
CLEAR APERTURE:	3.5 inches, 89mm (Center Obscuration, 27.9mm)
FOCAL LENGTH:	Basic Visual 50.5 inches, f/14.4, 1300mm
FOCAL LENGTH:	Camera close, 56 inches, f/16, 1400 mm
FOCAL LENGTH:	Camera with Ext. Tubes, 64 inches, f/18, 1600mm
FINDER LENS:	4" Fl., 4x and 8x, Field 12° and 8°
POWERS:	Powers are eyepiece dependent and can range from 40x to 270x with Questar Brandon eyepieces
POWERS LIMIT:	Resolves 1 sec. Arc at 50feet EFL
FIELD OF VIEW:	Photographic model, 1°30min, visual field of view 1.1° to .16°
LENS:	BK7, $MgFl_2$ coated, passes UV to 3300 A, IR to 1 micron, parfocal
MIRROR:	F2, Pyrex®, Zerodur® or Quartz. AlSiO coated 3.800" dia. (All Questars for UV or IR on special order)
SPECIAL COATINGS:	On special order, broad-band dielectric coating applied to the mirror, which increases its reflectivity. To both sides of front lens, a very low reflection coating is then applied which reduces the light loss at each surface to less than 1/10 of 1%. It transmits all frequencies of the visible spectrum and improves total light grasp by approximately 22%
EYEPIECES:	24 mm Brandon, 45° ap. Field; 16 mm 4 lens Brandon, 45°Ap. Field, optional eyepieces of 8mm, 12mm, 32mm
AMPLIFYING/BARLOW LENS:	Minus 43.9 mm FL
ERECTING SYSTEM:	Star Diagonal type, 90° BK7, $MgFL_2$ coated
BARREL ASSEMBLY:	Barrel: forged aluminum, machined full length
LENS CELL:	Aluminum 24S-T4, black anodized
REAR CLOSURE PLATE:	Stainless steel CENTRAL TUBE - precision machining and alignment after assembly.

DEWCAP:	Internally black-flocked Synthane seamless tube 1/32" thick, to which is bonded a pre-rolled aluminum sheet
FOCUSING MECHANISM:	Mirror thimble, stainless steel sliding tube. Slides on stainless, fixed, light-baffle tube, with front-end insert tube of .010" wall thickness. Conical ss spring-loaded. Focus rod ss 303, ground shaft, 56 T.P.I. precision ground threads
KNOBS:	Aluminum 24S-T4, corrosion-resistant, hand-turned on turret lathe, stainless steel shafts and levers.
EQUATORIAL MOUNT:	Aluminum sand casting, virgin alloy 356-T6 heat treated. Toolroom hand-turned and polished. Highly corrosion-resistant. Jig-bored and precision threaded for legs. Bottom flange 7" o.d. Fits tripods with _-20 threads
TURNTABLE OR LOWER FORK BASE:	Sand casting same alloy, toolroom turned, jig-bored and precision-reamed, aircraft polyurethane painted
LEGS:	Aluminum 61 S-T3, centerless-ground and threaded, anodized. Center leg adjustable. Butyl rubber tips
SYNCHRONOUS DRIVE MOTOR:	_ R.P.M. 110V. 60 cycles, other cycles, voltages and direction of rotation available. Sealed, lubricated gear train, 2.7 watts
RIGHT ASCENSION GEAR:	Bronze, 4" diameter, and 4" diameter teflon-facing bearing surfaces
SIDE ARMS, INNER FORK BRACKETS, CONTROL BOX:	Die castings of corrosion-resistant aluminum alloy 13, toolroom turned, milled, jig-bored, tapped and reamed. Special painted aluminum and clear-urethane protected
FINDER MIRROR CAGE:	stainless steel, brushed satin finish
ALTITUDE OR DECLINATION CIRCLE:	3-15/16" diameter, 301 s.s., cemented and riveted to bracket ring assembly, 1° divisions with etched and filled markings
CLAMP:	Bakelite padded s.s. stud clamps dec. circle to side arm
AZIMUTH OR R. A. CIRCLE:	6" diameter, anodized aluminum, silk-screened, graduated to 1° and 4 min of time. May be set as celestial clock. Manual slow-motion independent of drive
SLOW MOTIONS:	Continuous 360° rotation, safety clutch held. Permits control to a few seconds of arc. Absolutely free of backlash, lag, or play. Ratio 31 to 1
TUBE & MOUNT INTERFACE:	Dual axial alignment pins, precision milled mounting surface and _-20 thread knob with knurled O.D.
DIMENSIONS:	Height, upright, 14". With barrel horizontal, 11" high and long. Weight, 6.7 pounds



TYPICAL MTF FOR QUESTAR 3½-INCH

Typical Questar 3½ and Seven Modulation Transfer Function (MTF) as obtained with a shearing interferometer and expressed as a function of the shear parameter, S. To express the MTF as a function of the spatial frequency, R, in lines per millimeter, the following relationship can be used:

$$R = \frac{SD}{2\lambda f}$$

where S = shear parameter, λ = wavelength, f = focal length, and D = clear aperture.

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Email: Questar@erols.com

Sources:

http://www.company7.com/questar/index.html
http://www.company7.com/library/questar/notes.html
http://www.astrosurf.com/luxorion/Illustrations/questar-catalog-1972.pdf
https://www.questarcorporation.com/QuestarPDF/QuestarHistory.pdf

THE KEW PHOTOHELIOGRAPH

PEDRO RÉ
http://pedroreastrophotography.com/

The Kew Photoheliograph (Figure 1) was the first telescope specifically designed for solar photography. It was commissioned in 1854 and named after the Kew Observatory where it has housed.

The Photoheliograph was designed by Warren De la Rue (1815-1889) (Figure 2) for the London Royal Society in 1857 and made by Andrew Ross (1798-1859). It was mainly used for daily photography of the Sun at the Kew Observatory and the Royal Observatory of Greenwich. It was also transported to Rivabellosa in Northern Spain where it was used to photograph the Total eclipse of the Sun on July 18th, 1860.

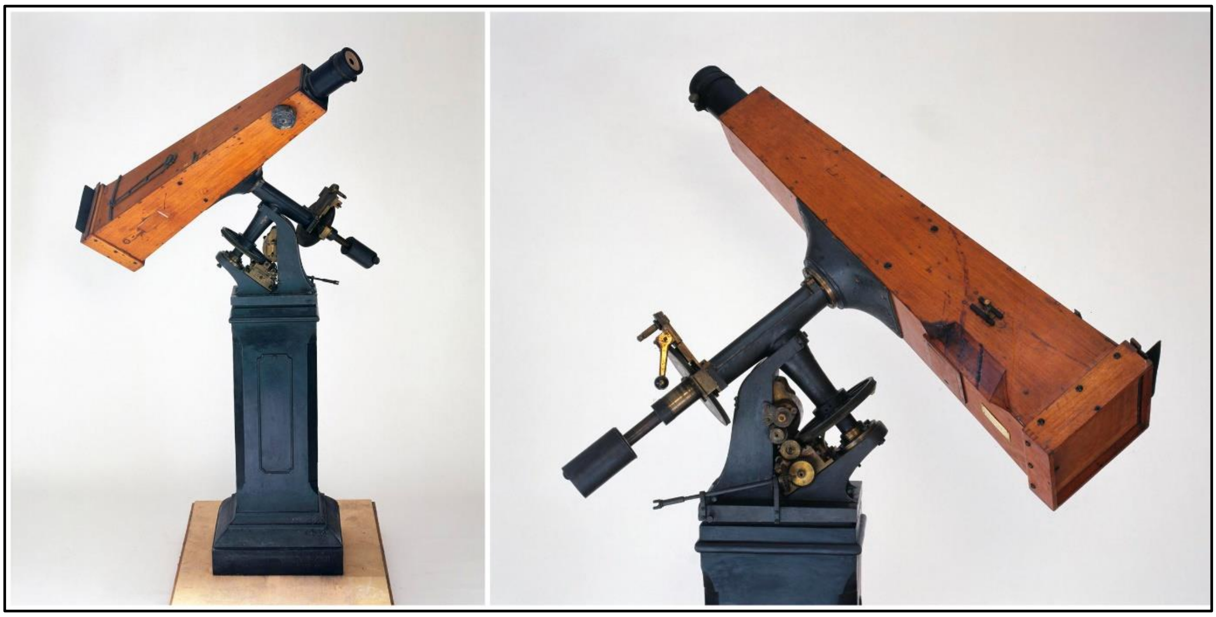

Figure 1- The Kew Photoheliograph.

The first solar photographs were obtained by Hippolyte Fizeau and Leon Focault in 1844. The first photographs of the partial phase of a total solar eclipse and of the solar spectrum were also obtained in the 1840s. In 1849 Hervé Faye made an important communication to the Frech Academy of Sciences proposing the continuous photographic survey of the Sun:

If a solar image is formed in the daguerrotype plate ... the same measurements can be repeated later on and compared with contemporaneous ones ... The same procedure may be applied to the determination of the heliocentric sunspot co-ordinates ...

On April 24, 1854 John Herschel wrote to Edward Sabine:

I consider it an object of very considerable importance to secure at some observatory, and indeed at more than one, in different localities, daily photographic representations of the sun, with a view to keep up a consecutive and perfectly faithful record of the history of the spots.

Herschel's idea was followed, and a grant was given to Warren de la Rue for the construction of the photoheliograph for the Kew Observatory. The telescope was operational in 1856[11] and it was initially referred as "the sun-spot photographic apparatus". It subsequently became know as the Kew Photoheliograph.

Figure 2 – Warren de la Rue.

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[11] The photoheliograph did not become fully operational until March 1858. It was not used on a daily basis until several years later.

The Photoheliograph was described in an 1857 report (Kew Observatory):

The object-glass of this instrument is 3 $^{4}/_{10}$ inches aperture and 50 inches focal length; it is not corrected for achromatism in the ordinary manner, but so as to produce a coincidence of the visual and photogenic foci. The secondary objectives for magnifying the image produced by the principal object-glass are of the Huyghenian form. They are three in number, producing respectively images of the sun 3, 4, and 8 inches in diameter. Between the two lenses of each of these secondary object-glasses is inserted a diaphragm-plate carrying the fixed micrometre wires, which are of platinum; these wires are four in number, two at right angles to the other two. One of the wires of each pair is in such a position that they may both be made tangential to the sun's image, while the other two crosses at a point situated near the sun's centre. By means of these wires, the distance in arc between each pair having been once for all ascertained astronomically for each secondary object-glass, it will be easy to determine all the data necessary for ascertaining the relative magnitudes and positions of the sun's spots. These micrometre wires are under the influence of springs, to preserve a tension upon them when expanded by the sun's heat, and thus to keep them straight.

The principal and secondary object-glasses are not mounted in an ordinary cylindrical tube, but in a pyramidal trunk square in section, 5 inches in the side at the upper end, which carries the principal object-glass, and 12 inches in the side at the lower end, which carries the photographic plate-holder and the usual ground glass screen for focusing.

This trunk is firmly supported by a declination axis of hard gun-metal 2½ inches in diameter; it is furnished with a declination circle 10 inches in diameter, reading to one minute of arc, and has a clamp and screw motion for fine adjustment in declination.

The declination axis works in Y-bearings at the top of the polar axis, which is 12 inches long; it is 4 inches diameter at its upper end and I½ inch at its lower end. The lower end fits with a slight taper into a brass collar up to a shoulder, the friction being reduced by a steel spring plate pressing against a hardened steel hemisphere at the end of' the axis.

It will be seen by the above description, that every precaution has been taken to secure stiffness in the telescope combined with freedom in the motion of the polar axis. The polar axis is driven by a clock driver, which answers perfectly, and is easy of regulation to the greatest nicety, so that the sun's limb remains for a long period in contact with the tangential wires. Near the lower end of the polar axis is fixed the hour-circle, which, like the declination circle, is 10 inches in diameter; it is graduated to read to 2 seconds of time. An endless screw, making about two revolutions in one minute, gears into the hour-circle and connects it with the clock. As it is generally necessary to make small corrections in right ascension after the tangent screw has been geared with the driving clock, in order to bring the sun's image in position with respect to the micrometre wires, a sliding plate is provided which carries the bearings of the tangent screw; this is acted upon by a second fine screw parallel with the tangent screw; so that by rotating the second screw, the sliding plate and the tangent screw are moved through a small space, and the hour-circle thus caused to rotate to the extent necessary for bringing the sun's image in position.

The clock is driven by two weights, one pulling upwards over a pulley, the other downwards, thus suspending the barrel and equalizing the pull and avoiding friction on its bearings. By causing the click of the winding lever to abut on the ratchet-wheel of the going part of the clock during the period of winding, the clock goes at its normal speed while it is being wound.

The mode of regulating the clock is extremely simple and efficacious; it is effected by approaching to, or withdrawing from, a hollow cone over a small wheel, on which are attached, by means of flat *springs, two small weights, which expand by centrifugal force and come in contact with the inside of the hollow cone.*

The polar axis of the telescope is carried by a dial-plate which fits on the top of a hollow column of cast iron, the section of which is a parallelogram. This column is securely fastened to the stone foundation. The instrument is mounted within the rotating dome of the Kew Observatory, which has been repaired and put for that purpose. photographic dark room is at present too distant from the telescope, but it is contemplated to construct close to it, as serious inconvenience has been already experienced in the preliminary experiments in consequence thereof.

The telescope and its mechanical appliances may be said to be perfect so far as they go, but experience will undoubtedly suggest several minor alterations and additions before the telescope is brought practically to work. The photographing of such minute objects as the sun's spots will always require the utmost skill and care of an accomplished photographer, even when the telescope has been fairly started. The difficulties yet to be mastered must occupy some considerable time. The first attempts have been confined to the production of negative photographs, but in consequence of the imperfections always existing in the collodion film, it has been deemed advisable to make attempts to produce positive pictures, and recourse may ultimately have to be made to the Daguerreotype process.

Warren de la Rue also described how the instrument for photography:

It has been found, after repeated trials, that the best photographic definition is obtained when the sensitized plate is situated from 1/10th to 1/8th of an inch beyond the visual focus in the case of a 4-inch picture; and that when this adjustment is made, beautiful pictures are obtained of the sun 4 inches in diameter, which still bear magnifying with a lens of low power and show considerable detail on the sun's surfaces besides the spots, which are well defined.

The image is not received directly on the sensitive plate, as is the case in taking lunar and planetary photographs, but is enlarged before it reaches the plate, by means of a secondary lens, which magnifies the sun's image to about four inches in diameter. The time of exposure is so short, that there is a necessity for a special contrivance for regulating the time of exposure. This is effected by means of a sliding-plate placed just before the secondary lens. In this plate is a slit which is adjustable in width. The plate before taking the picture is held up by means of a thread. In this position the light is shut off from the sensitive plate. When the picture is about to be taken the retaining, thread is set fire to, and a spring pulls the plate rapidly across the secondary lens. The time of exposure depends on the rapidity of passage of the sliding-plate before the secondary lens.

In 1860 The Kew Photoheliograph was transported to Rivabelossa in Spain to photograph the Total Solar Eclipse (July 18) (Figure 3). A new Iron Pillar with the latitude of Rivabelossa was build and a portable observatory was also constructed (measuring 8.5 square feet and 7 feet high). The observatory was open at the top and included a photographic dark room[12].

In 1860 it was not known if the solar prominences were part of the sun or an atmospheric phenomenon. By comparing the photographs obtained with the Kew Photoheliograph with those obtained by Angelo Secchi (in Las Palmas 500 km away), Warred de la Rue proved that the prominences intrinsic to the Sun (Figure 4).

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[12] *The Bakerian Lecture: On the Total Solar Eclipse of July 18th, 1860, Observed at Rivabellosa, Near Miranda de Ebro, in Spain*. Warren de la Rue, *Phil. Trans. R. Soc. Lond*. Vol. 152, pp. 333–416 (1862)

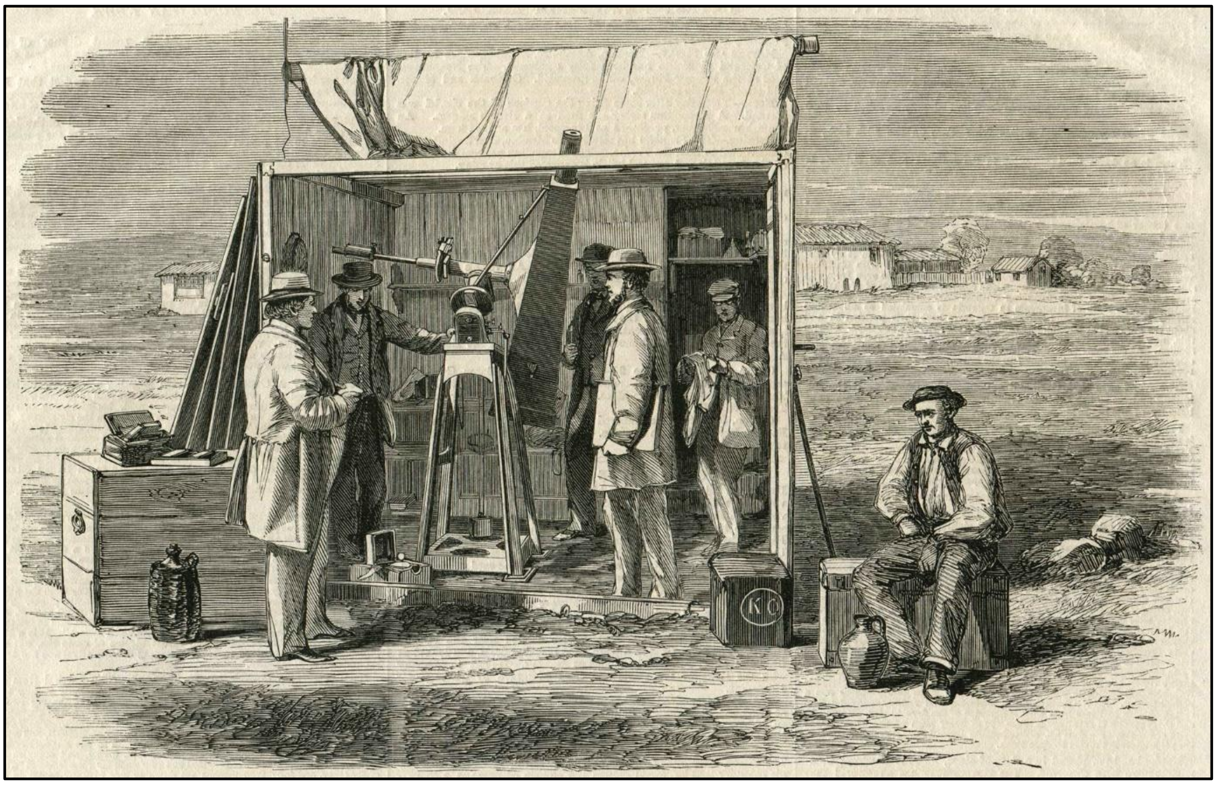

Figure 3- The Kew Photoheliograph at Rivabellosa, Spain.

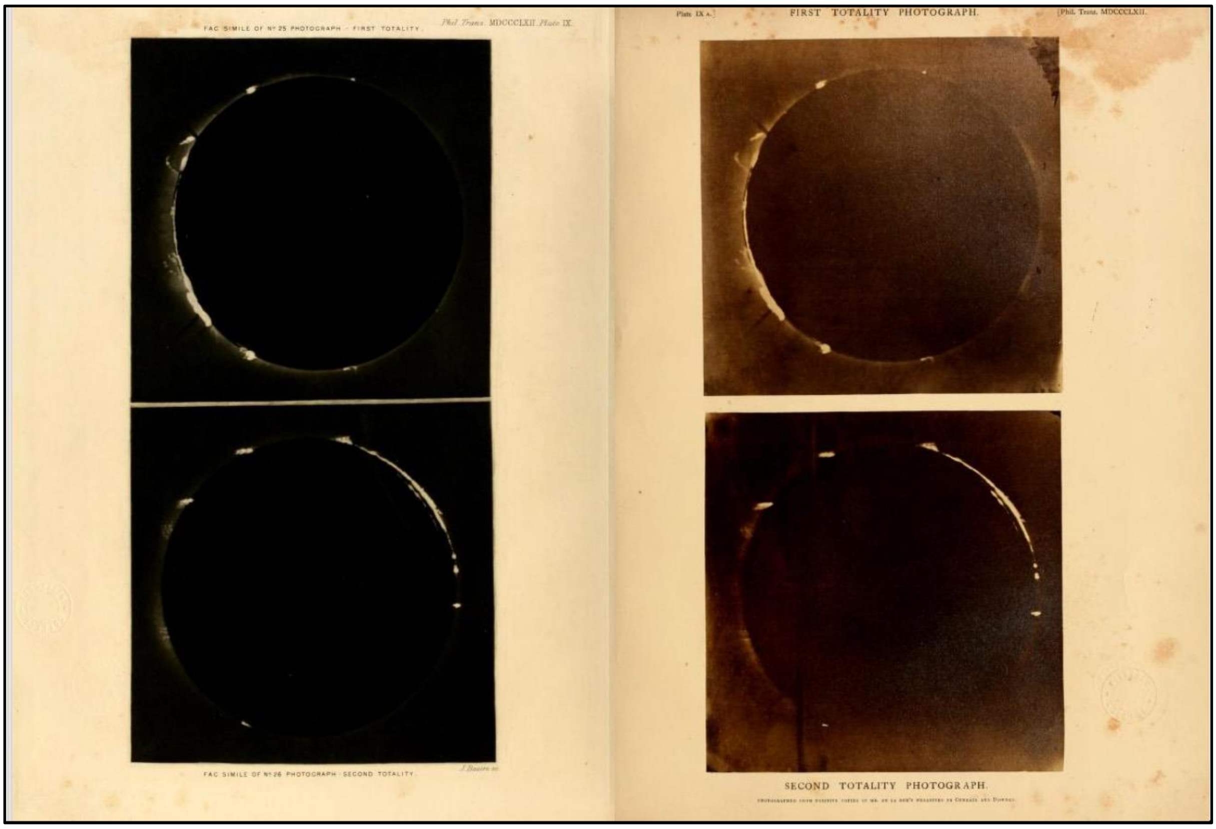

Figure 4- Photographs of the Total Solar Eclipse obtained with the Kew Photoheliograph.

After the Spain Eclipse, Warren de la Rue used the instrument in his private observatory in Cranford. The first photographs were obtained on February 7, 1862. After this the Photoheliograph was used in a daily basis ate Kew from 1863 onwards.

A ten-year solar photography programme was started at the Kew Observatory. From 1863 to 1872 the Photoheliograph was used regularly at Kew (Table 1) (Figure 5).

Table 1- number of days on which photographs were obtained at Cranford and Kew[13].

Year	Days	Comment
1862	163	Pictures taken at Cranford
1863	125	Instrument returned to Kew in Feb, pictures recommenced May
1864	164	
1865	159	
1866	157	
1867	131	No pictures taken during building works (9 Aug – 9 Sep)
1868	174	
1869	195	
1870	220	
1871	226	
1872	10	Figures relate to January only. The programme ceased a few weeks later
Total	**1724**	

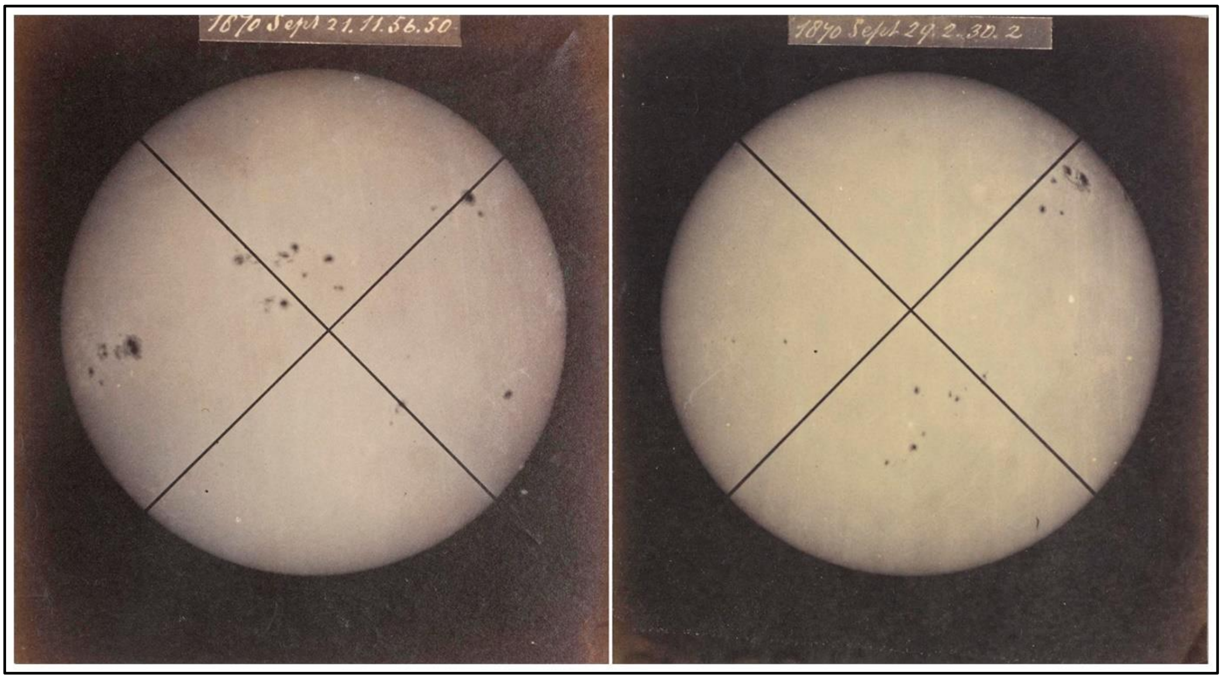

Figure 5- Solar Photographs taken by Elizabeth Beckley in 1870 with the Kew Photoheliograph[14].

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[13] *Monthly Notices of the Royal Astronomical Society*, Feb 1872 (Vol. 32, p.156).

[14] Elizabeth Beckley, the teenage daughter of the observatory's mechanical engineer, was employed cheaply to take daily photographs of the Sun. She went on to work at Kew for over ten years and was one of the first female employees of an astronomical observatory. Warren De La Rue praised her ability to capture photographs 'even on very cloudy days, when it would be imagined that it was almost impossible'.

The 1874 Transit of Venus was also photographed with the Kew Photoheliograph. the observatory's Board of Visitors determined that:

Mr. Warren De la Rue be requested to confer with the Astronomer Royal with the view of organizing a plan for photographic observations of the Transit of Venus, and for preparing an approximate estimate of the probable expense.

And also:

Resolved, that as this Board deem it most important that Photographic be combined with eye observations at the approaching Transit of Venus, an opinion in which the Astronomer Royal fully concurs, the Chairman [Edward Sabine] apply to the Lords Commissioners of Her Majesty's Treasury to sanction a grant of Five Thousand Pounds (£5000) for the purpose, a sum which it is considered will cover the cost of photographic apparatus and observations for all stations.

The Photoheliographic programme of the Royal Observatory ran at Greenwich from 1873 until 1948 (Figure 6) and at Herstmonceux from 1948 until the end of 1976 when it was formally brought to an end by Richard Woolley. Given the importance of the work, it was taken up by the Heliosphysical Observatory, Debrecen, Hungary, where a programme of observations continues to this day.

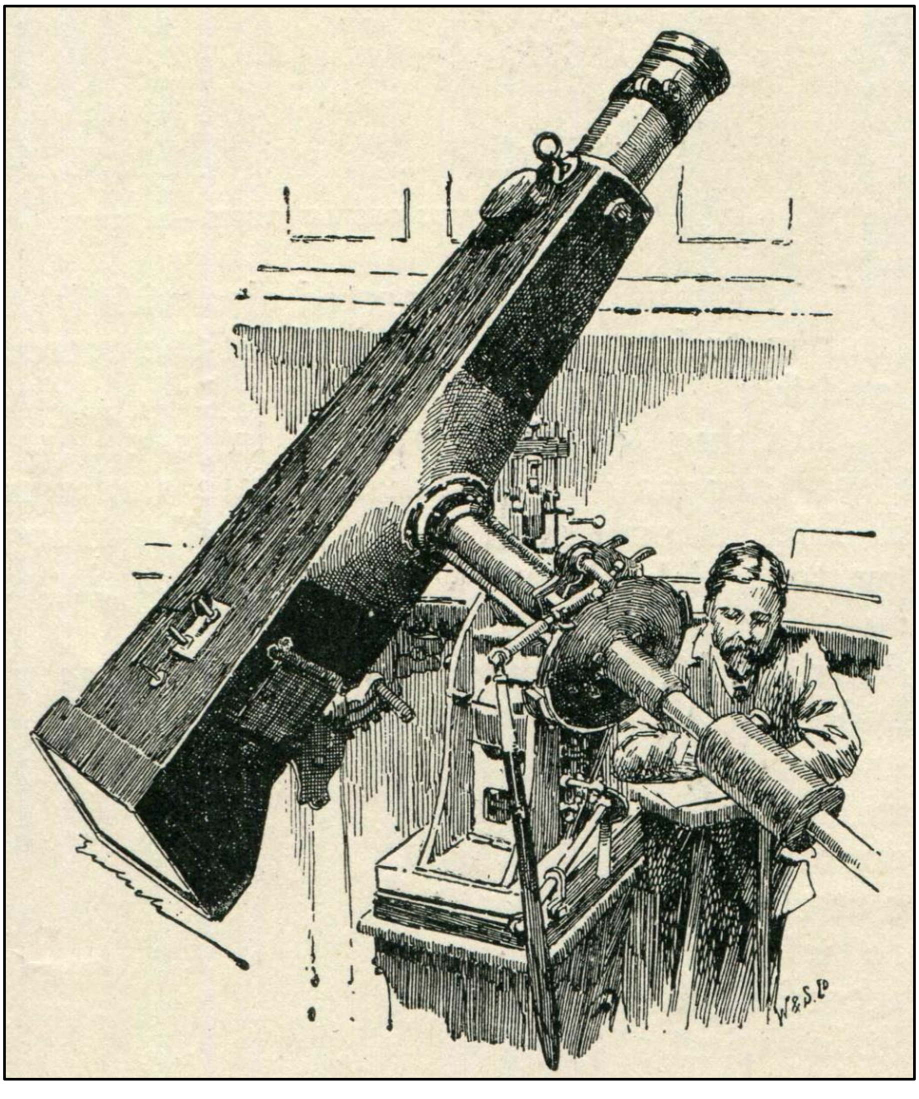

Figure 6- The Photoheliograph in its dome at Kew.
Weather Watchers and their Work, *The Strand Magazine*, Vol.3, London, 1892, p.185

In 1876 the Photoheliograph was installed in a dome and a few weeks later, it was dismounted and sent on Loan to and Exhibition at South Kensington. There it remained until 1882 when it was once again returned to Kew. It was used after 1882 to record sunspot positions visually as they appeared projected on to the focussing screen. The new programme with the Kew Photoheliograph continued for 15 years before being brought to a close at in 1897. Over this period, the average number of days in each year on which observations were made was about 170. This was considerably lower than the number of days each year on which good photographs were obtained at Greenwich.

Since 1927, the instrument has been in the care of the Science Museum in London (Figure 7).

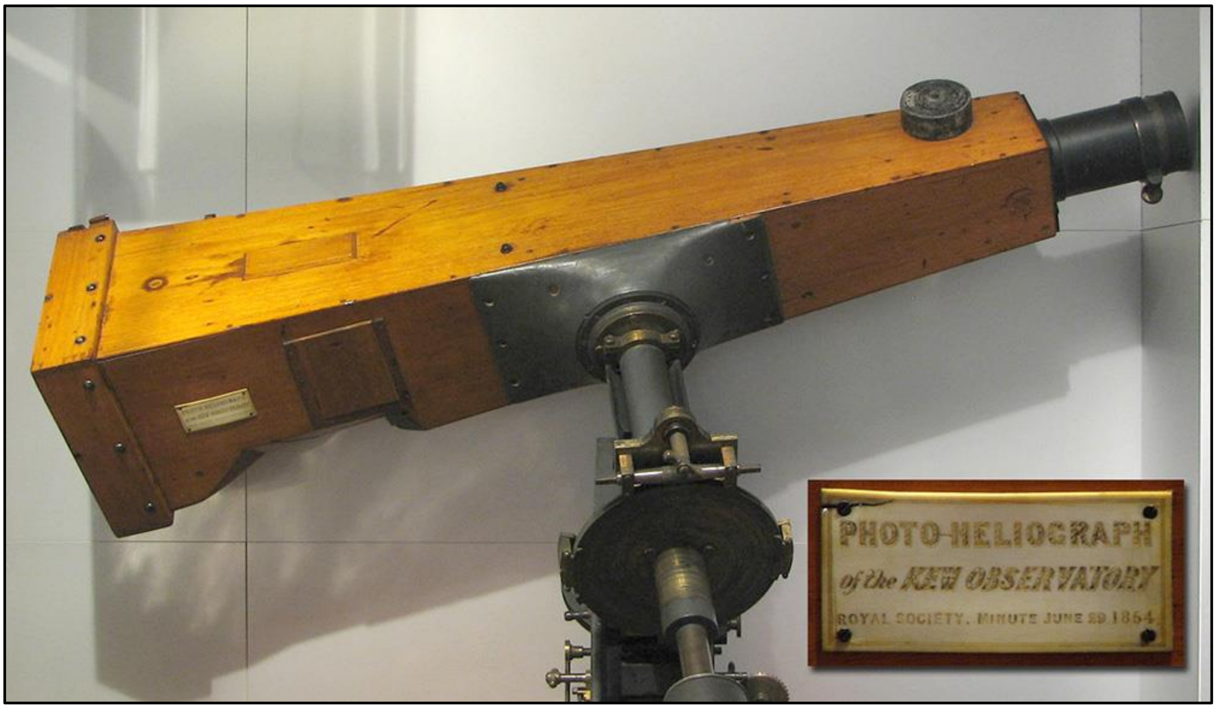

Figure 7- The Kew Photoheliograph on display in the Science Museum (2016)

Sources:

The Bakerian Lecture: On the Total Solar Eclipse of July 18th, 1860, Observed at Rivabellosa, Near Miranda de Ebro, in Spain. Warren de la Rue, *Phil. Trans. R. Soc. Lond*. Vol. 152, pp. 333–416 (1862).

On Celestial Photography. Warren de la Rue, *Monthly Notices of the Royal Astronomical Society*, Vol.19, pp.353–358 (1859).

The Greenwich Photo-heliographic Results (1874 – 1885): Observing Telescopes, Photographic Processes, and Solar Images. D. M. Willis, M. N. Wild, G. M. Appleby & L. T. Macdonald. *Sol Phys* (2016).

http://www.royalobservatorygreenwich.org/

AUTOMAÇÃO ROBÓTICA DE EQUIPAMENTO DE OBSERVAÇÃO ASTRONÓMICA: UM CASO IOT

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Em Junho de 2018 publicámos um trabalho sobre automação robótica de equipamento de observação astronómica, considerado pioneiro, dadas as circunstâncias em que se desenvolveu e o seu carácter experimental, uma vez que também se iniciavam pela primeira vez tentativas de aplicação do Raspberry pi a projectos de automação no âmbito da astronomia amadora.

Julgamos que hoje a sua divulgação pode ter interesse, uma vez que continua a despertar junto da comunidade de astrónomos amadores, uma procura redobrada, evidenciada pelas aplicações comerciais que então surgiram, como o ASIair.

Por outro lado, poderá contribuir com pistas e dicas, algumas já ultrapassadas pela evolução tecnológica, passados estes dois anos, mas que revela também a engenhosidade da astronomia amadora.
Em 2018 a aquisição de uma montagem equatorial alemã iOptron CEM60 dotada de um Hub USB com fornecimento de energia 12volts fez-me pensar em automatizar a sua operação bem como todos os dispositivos conectados à mesma, nomeadamente as camaras CMOS/CCD de aquisição de imagens e de guiagem, assim como o sistema de focagem e um simulador do céu/planetário tipo SkySafari ou o Kstars.

A montagem e o tripé (antes e depois)

Surgiram na altura duas ofertas no mercado, com características de grande portabilidade e de crescimento modular e ainda de baixo custo. Uma de origem koweitiana (designada por StellarMate IoT), outra de iniciativa francesa (AstroPiBox) tinham por base a placa Rasberry Pi 3, que entretanto ganhava popularidade e se expandia em aplicações de toda a ordem, chegando a Estação Espacial Internacional a estar dotada de dois RB Pi para software concebido pelas escolas.

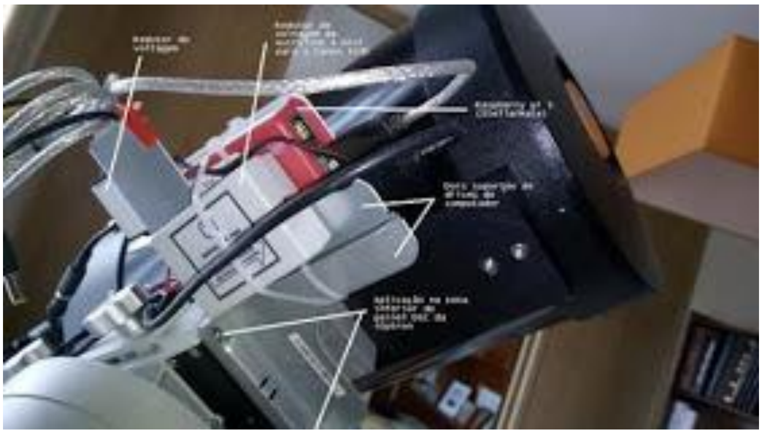
A nossa opção centrou-se no IoT (Internet of Things) StellarMate dado apresentar-se com integração de meios e software (firmware) nomeadamente o conjunto Kstars/Ekos/INDI sob qualquer plataforma Windows/Linux/OSX/Android.

Kstars é um simulador do céu, tipo planetário, com origem na iniciativa KDE-edu enquanto o **Ekos** constitui um ambiente de controlo integrado que permite a gestão de um conjunto de operações desde a aquisição de imagens e de guiagem até ao controlo de qualquer dispositivo de utilização astronómica (câmaras CMOS/CCD, rodas de filtros, sistemas de focagem, montagens, desembaciadores, Flip-Flat, espetrógrafos, óticas adaptativas, estações meteorológicas, GPS, observatórios, astrometria de precisão, alinhamento polar, operação robótica à distância, etc).

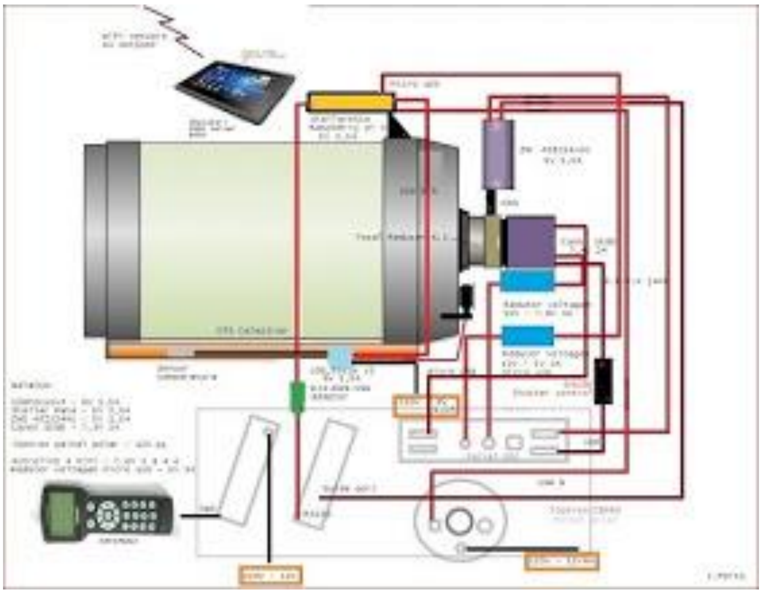
INDI constitui a coluna vertebral de todo o sistema porque é um servidor que assegura a comunicação kstars/Ekos com os “drives” de todos os periféricos em simultâneo.

O RB Pi3 da StellarMate inclui já um microcartão SD de 16GB de classe 10 com todo o software. Acionámo-lo a partir de um Tablet Android ASUS de 10 polegadas e configurámos o StellarMate e a iOptron CEM60 com toda a cablagem USB, redutores de voltagem e amperagem e ainda adaptadores porta-série RJ4/DB9/USB necessários para a sua operação eficaz.

Quisemos dotar a montagem iOptron CEM60, possuidora de um sistema inovador de balanceamento denominado **“Center Balanced Equatorial Mount”,** com a possibilidade de alternar com a instalação de diversas óticas como um Celestron 203mm ou um Takahashi 102FS ou ainda um refrator 66/400. Para tal tivemos que aplicar na montagem um suporte que acondicionasse o StellarMate bem como outro equipamento que descreveremos mais adiante.



Sistema mecânico de suporte ao Rasberry Pi3 e redutores de voltagem



Esquema geral definitivo do fluxo de dados e dos circuitos elétricos (com o C8 como óptica)

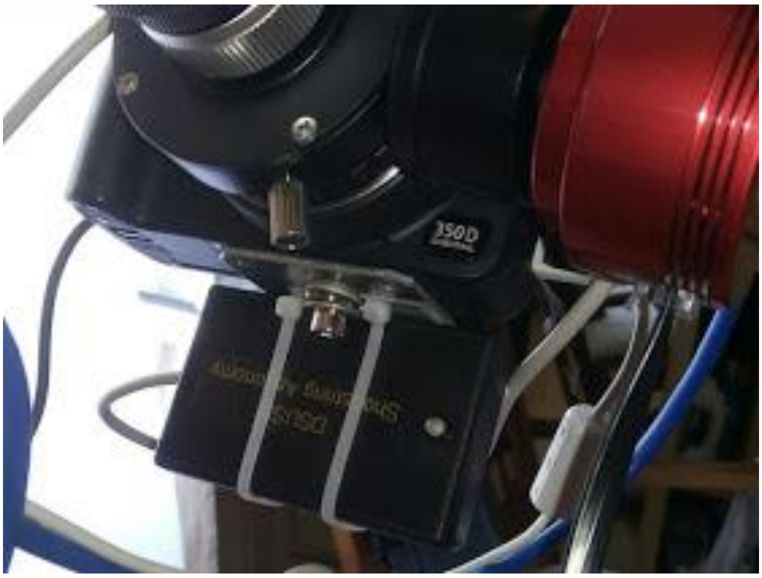
Como equipamento de aquisição de imagens tínhamos a velha **Canon 350D** desfiltrada, com sensor CMOS de resolução 3464 x 2309 píxeis e 6,41 microns de pixel pitch, e, à qual foi necessário adaptar um cabo a ligar a bateria de lítio a um redutor de 12 volts fornecidos pelo painel DEC da montagem iOptron convertendo-os para 7,6 volts e 2 amperes através de duas fichas macho/fêmea de 5,5/2,1. Usando solda e ferro de soldar e depois de identificadas a polaridade dos fios foi fácil conceber esta ligação. Tivemos a preocupação de arranjarmos um redutor de voltagem que se situasse entre os 7 e 8 volts e fornecesse os 2 amperes para não "fritar" a bateria da Canon.

A Astrolink 4 Mini possuía um redutor deste género devidamente protegido e destinado a camaras DSLR.

A Canon 350D agregada a um OAG juntamente com a ZWO ASI224mc como câmara de guiagem

Da Canon 350D fizemos uma ligação ao DSUSB da Shoestring com a Canon em Bulb e M Mode *(cabo coaxial com jacks machos respetivamente de 3,5mm/2,5mm tipo E3),* ligando depois diretamente o gadget DSUSB através do seu próprio cabo USB 2.0 ao painel DEC da iOptron.

Para transferência de imagens ainda tivemos de ligar a micro USB da Canon a outra porta USB do Painel DEC da iOptron (ver esquema). Na plataforma INDI introduzimos a definição DSUSB na porta de comunicação.



Esquema de suporte da DSUSB à Canon 350D

Experimentámos o QuickRemote desenhado por Christian Buil sem sucesso, enquanto o interface usb-eos para exposições longas (acima de 30 segundos) comercializado pela PierreAstro funcionava perfeitamente com a adição de mais um cabo USB entre a Canon e o DEC da iOptron para transmissão das imagens.

No **painel polar da iOptron CEM60** fazíamos sair um cabo USB B/ USB A ligando ao StellarMate fazendo assim a comunicação de dados entre os dois. Ainda ao painel polar fornecíamos energia 12 volts 6 amperes com um transformador.

A camara de guiagem **ZWO ASI224mc** montada num OAG (Off-Axis-Guider) ligava diretamente a sua porta ST4 à porta “Guide” na própria montagem, enquanto o cabo USB B da ASI ligava a uma porta USB do painel DEC da iOptron CEM60.

No **StellarMate** ligavam diretamente os cabos USB A do motor de focagem, USB_Focus_V3, e da própria montagem iOptron com cabos adaptadores RS232/RJ4/DB9/USB A, dado que tanto a montagem como o focador tinham fornecimento de energia independentes não sobrecarregando o StellarMate. Ao StellarMate era fornecida energia 5V 2,5 amperes a partir dos 12 volts do painel DEC da iOptron através de um redutor de voltagem e com cabo micro-USB.

Aspecto das ligações ao StellarMate e ligação RJ4/DB9/USB da montagem iOptron

Aspecto do painel DEC da iOptron com saídas para a Canon, ZWO, voltagens para Canon e StellarMate

Ao sistema de focagem **USB_Focus_V3** adaptámos um conjunto de placas metálicas adquiridas na AKI e que, com alguns parafusos e anilhas de aperto, dispúnhamo-lo de forma apropriada a permitir ao motor poder fazer a focagem sem stress mecânico.

Sistema de focagem instalado permanentemente no DEC da ioptron permitindo alternar com diferentes ópticas.

Em termos de potência elétrica instalada, tivemos o cuidado de ter um conjunto devidamente balanceado de modo a que tanto o fluxo de dados como as amperagens estivessem distribuídas devidamente e não causassem ostáculos operacionais:

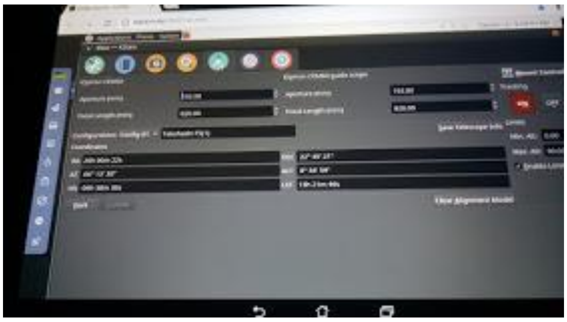
iOptron painel polar – 12V 5Amp / Transformador – 12V 6Amp
USB_Focus_V3 – 8V 1,5Amp com o seu transformador próprio
StellarMate – 5V 2,5Amp / Redutor Voltagem – 5V 3Amp
Canon 350D – 7 a 8V 2Amp / Astrolink 4 Mini – 7,6V 3 a 4Amp
ZWO ASI224mc – 5V 1,5Amp

Reguladores de voltagem para a Canon350D e para o StellarMate

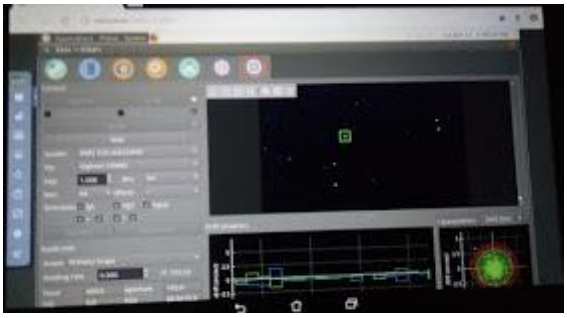
Kstars/Ekos/INDI – a coluna vertebral

INDI Web Manager mostrando a atribuição definitiva de portas-série de comunicação RS232 para a montagem iOptron CEM60 e para o USB_Focus_V3 (este último foi retirado depois porque não era preciso)

Alguns parâmetros de controlo Ekos da montagem



Autoguiagem com o Ekos com alinhamento polar e correção apenas a duas estrelas



SkySafari controlando a montagem e mostrando o FOV do sensor

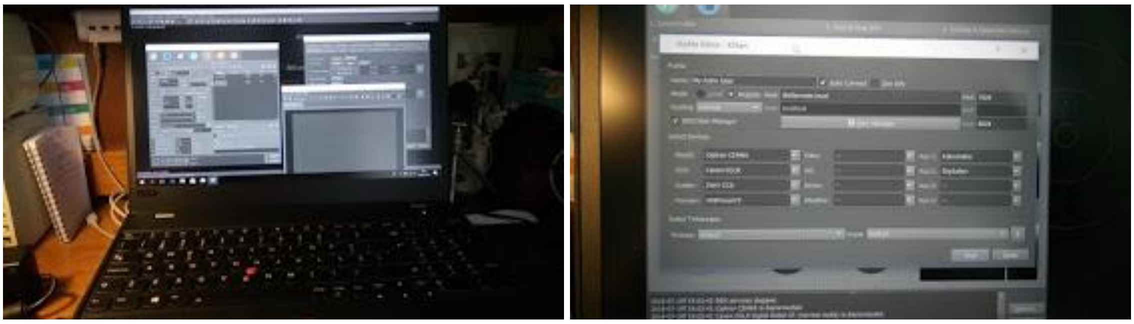
As configurações óticas C8 f/6.3 e doTakahashi 102FS f/8

As resoluções obtidas em segundos de arco por pixel para as duas óticas com OAG.
Os sensores CMOS da Canon 350D e da ZWO ASI224mc permitem obter valores rácio idênticos de 1:0,59

Os dois sistemas em funcionamento na mesma montagem equatorial alemã

Em conclusão:

A utilização integrada de um simulador do céu (Kstars) a partir do qual se tem acesso ao controlo automatizado de todos os dispositivos numa única página como o faz o Ekos, utilizando a “INDI Library” através do ubuntu 15.10, constitui um bem precioso e inestimável que se reflete na operacionalidade simples e amplamente portátil do conjunto com um Tablet/Smartphone via rede WiFi ou pela criação de um Hotspot pelo próprio Rasberry Pi 3 (neste caso comercialmente designado StellarMate). O seu valor acresce ao estar dotado também com um cartão micro SD com 16GB que permite guardar as imagens adquiridas para posterior processamento ou já com o pré-processamento feito ou permitindo a utilização de outros simuladores do céu como o SkySafari ou o Stellarium (referidos como dispositivos Auxiliares pelo Ekos).



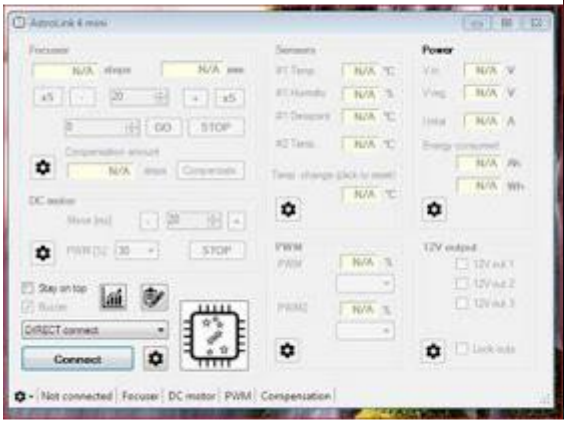
Controlo via WiFi da rede local todo o equipamento com um portátil Lenovo em ambiente Windows 10 depois de estabelecida ligação com o Stellar Mate alojado num Tablet android em ambiente linux/ubuntu.

Indi Library possui um Forum de apoio aos utentes e atualizações frequentes abarcando cada vez mais dispositivos a controlar. Jasem Mutlaq é o seu mentor e obreiro principal.

Outras expansões possíveis

Na altura a instalação de um outro IoT, denominado AstroLink 4.0 Mini permitiu ainda adicionar outros dispositivos como cintas desembaciadoras ou mesmo abdicar do transformador do focador USB_Focus_V3 abastecendo-o dos 8 volts necessários ao seu funcionamento através de uma saída de voltagem regulável.

O software do AstroLink 4.0 Mini permitiu parametrizar e gerir as saídas de voltagem tornando-as permanentes.



Como utilizador INDI (@fonsecaporto) quero deixar aqui um agradecimento caloroso ao sempre disponível Jasem Mutlaq, gestor da INDI Library, lançador do IoT StellarMate e astrónomo amador conhecedor das dificuldades práticas com as quais se defrontam diariamente todos os astrónomos amadores. Devo-lhe o seu esclarecimento pertinente a situações mais obscuras de algumas configurações. Também a ele se deve o seu empenho na atualização permanente e constante de todo o firmware e software.