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PART 1

Palomar Observatory is located on top of the Palomar Mountain about 145 km southeast of Los Angeles, California, owned and operated by Caltech. Its general plans were outlined in 1928-1929 when International Education Board of New York, with Dr. George Ellery Hale as its Chairman of the Council, has agreed to provide financing (Anderson 1942). In 1934, Palomar Mountain was selected as the site for the observatory after survey of more than a dozen of different sites in southern California, and construction has begun in 1935. The first operational telescope at Palomar was the 18” Schmidt Telescope proposed by Fritz Zwicky for his wide-field supernova surveys. The telescope saw the first light in September, 1936 already and was the observatory’s only operating telescope until 1949 (Palomar 2014). After 78 years in operation, Palomar is still an active observatory with its largest 200” Hale telescope being a workhorse of the modern astronomy. With an average of 290 clear nights per annum, the Palomar Observatory operates on a nightly basis for a wide range of astronomical studies, mostly conducted byCaltech’s faculty, post-doctoral fellows and students (NOAO 2011).

PART 2

Palomar observatory is present in the Astronomical Tourist web site. The location there is centered at the Hale Telescope dome.

PART 3

Palomar’s Hale Telescope was the world’s largest effective telescope for more than 40 years since it saw the first light in January, 1949 and until it was replaced by the 10 m Keck 1 telescope in March 1993, original idea of which was simply a scaled up version of its successful predecessor (Yarris 1992). The Hale’s primary mirror is D=200” (5.1 m) f/3.3 concave paraboloid made of Pyrex with focal length of 666” or 16.91 m (Anderson 1948). The light from the primary mirror is focused at the top of the telescope where instruments can be mounted at the prime focus, or light can be reflected back via hyperboloid convex secondary mirror to a Cassegrain f/16 focus, with effective focal length of 3,200” or 81.3 m. There are two additional focal points possible via two coudé hyperboloids of e=1.25 and D=36” and 32” that provide coudé focal length of 6,000” or 152 m. All secondary mirrors and diagonals are also made of Pyrex. The telescope is mounted on a so called horseshoe equatorial mount made of steel that allows unobstructed access to the north celestial pole, as opposed to English mount used on, for example, the 100” Hooker reflector at Mt. Wilson.

PART 4

a) Although the term “magnification” is generally used with visual observations, I don’t think the Hale has ever been exploited in that mode, with majority of its instruments being photographic. Assuming for the sake of experiment we take off the camera and insert an eypeice of a reasonbly short focal length, let’s say, 10 mm, used at the Cassegrain focus it would provide a magnfication of 81300 / 10 = 8,130X. The lower bound for the range of practical magnifications would probably be limited by the longest focal length eyepiece and the resulting exit pupil. I assume a reasonable eyepiece for that purpose would be of about 100 mm e. f. l., resulting in the 813X magnification and 6.3 mm exit pupil which should produce a very bright image. The upper bound would certainly be limited by atmosphere and the image contrast. The very short eyepieces (<10 mm e. f. l.) will produce maximum theoretical magnifications somewhere in the 10,000X—20,000X domain. On the ground, there is a practical rule among amateur astronomers as to the maximum magnification one can use to achieve steady images of reasonable contrast. The formula depends on the object being observed. For bright planets, for example, that will range from 1D to 2D (or even slightly more for high-contrast objects like Mars), that is converted to multiples of aperture in millimeters. With Hale's D=5100 mm, this will result in the 5,000X—10,000X domain upper bound.

b) It is worth to clarify that "brightness of image" or a focal ratio of telescope, as specified in the course content without further notes, can be misinterpreted as the brightness of image as perceived visually in the eyepeice, however this term is actually applicable only to photographic observations in terms of exposure durations required to reach a specific magnitude, with instruments mounted in the primary or secondary foci of a telescope. From this perspective, I will consider we're back using Hale as a photographic instrument. Focal ratios available are, thus, f/3.3, f/16 and f/30 at its coudé foci.

c) Again, we see some uncertainty as to how the telescope is supposed to be used – as a visual or a photographic instrument – because the term limiting magntiude, in the sense given in the course content, is generally used for visual observations through eyepiece. According to the formula provided, $L_m=2.7 + 5 \log_{10} D = 21.23^m$. Photographic limiting magnitude would be quite different and would depend on the exposure duration, sensitivity of the sensor (film), atmospheric seeing, light pollution and a number of other factors. We can see that a deeper L_m of 22.2^m was reported photographically a few years before Hale was commissioned using the 100" Mt. Wilson reflector that has four times less aperture area than Hale's (Whipple & Rubenstein 1942). Since Hale is still in use today with modern instruments and, especially, the new PALM-3000 adaptive optics system, its photographic limiting magnitude must be much higher (Dekany et al. 2013). As a quick example how modern instruments can improve telescope's ability to reach deep, I was able to observe a 22.46^m KAZF 5907-21 which is an extragalactic globular cluster belonging to the NGC 5907 galaxy, using only a 10" telescope, a modern CCD and only 115 minutes exposure – from the light-polluted center of Prague (Usatov 2011), see figure 1 below.

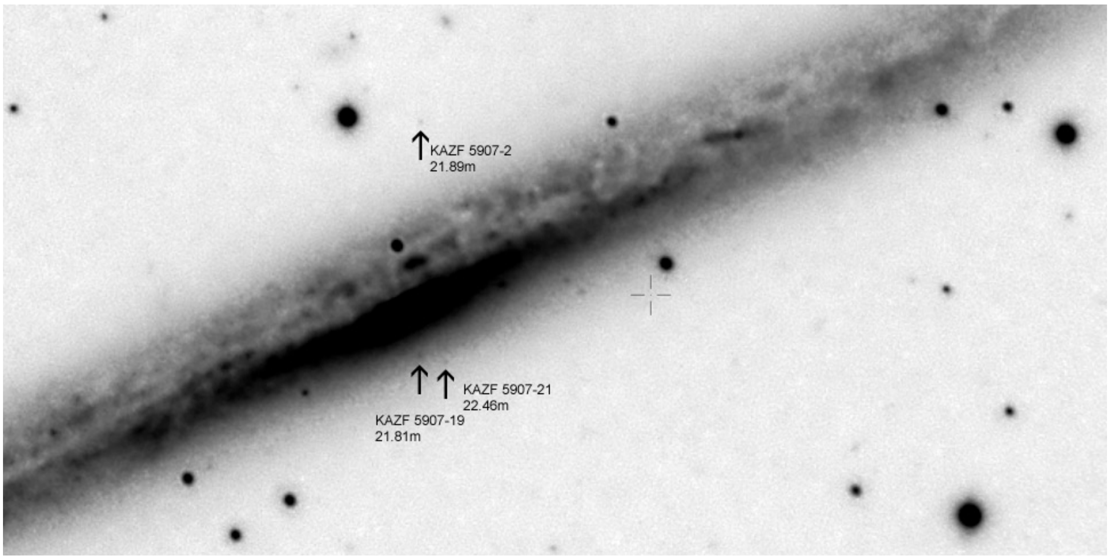

FIG. 1 – KAZF (Kissler-Patig+Ashman+Zepf+Freeman) extragalactic clusters in the NGC 5907 galaxy, as observed photographically with 10" telescope from Malvazinky Observatory in Prague. Negative image.

d) The photographic resolution would also depend on the type of sensor (or film emulsion) being used, as well as processing methods. The visual Dawes limit formula provides us with 116/D ~ 0.02" limit for Hale. In reality however, resolution is almost always limited by atmospheric conditions on Earth with the best sites having 0.5—1" seeing. It is worth to mention that the PALM-3000 adaptive optics system has increased the resolution capabilities of the Hale to the extent it now can photographically detect circumstellar discs, very close binary companions, such as ~1" separated Kappa Andromedae, as well as convey exoplanet studies and other research in the field of high-resolution astronomy.

RESPOND

I've checked Chris' calculations and found them to be correct.

REFLECT

I love coming back to Ondrejov Observatory that is located about 50 km south to Prague and belongs to the Academy of Sciences of the Czech Republic. It's a great site that features a wealth of historical telescopes – from small brass refractors and early reflectors and very strange objects like circumzenithals in a number of museums, to active 2 m Zeiss reflector, horizontal solar telescope and many radiotelescopes – all in a wonderful green area. See photos below. I would strongly encourage anybody on a tour to Europe to include Ondrejov in their itinerary, as it is truly an astronomer's paradise. Just keep in mind the doors are open only once a year, otherwise it's a fully functional scientific research facility.

REFERENCES:

-, 2014, Palomar Decommissioned Telescopes,
http://www.astro.caltech.edu/palomar/about/telescopes/decommissioned.html
-, 2014, The 200-inch Hale Telescope,
http://www.astro.caltech.edu/palomar/about/telescopes/hale.html
-, 2011, NOAO Palomar Observatory (Hale 5m Telescope),
http://ast.noao.edu/facilities/other/hale
Anderson, J. A. 1942, JRASC, 36, 5
Anderson, J. A. 1948, PASP, 60, 221A
Dekany, R., Burruss, R., Shelton, C. J., et al. 2013, in Proceedings of the Third AO4ELT Conference
Usatov, M. 2011, NGC 5907 - The Splinter, Spiral Galaxy in Draco,
http://www.bcsatellite.net/bao/NGC5907/ngc5907.html
Whipple, F. L., Rubenstein, P. J., 1942, PA, 50, 24W
Yarris, L. 1992, Research Review Magazine, http://www2.lbl.gov/Science-Articles/Archive/keck-telescope.html


Záhřebská tragédka Marija Strozzi na návštěvě v
Ondřejově - 1924
M.Strozzi u Šafaříkova dalekohledu v centrální
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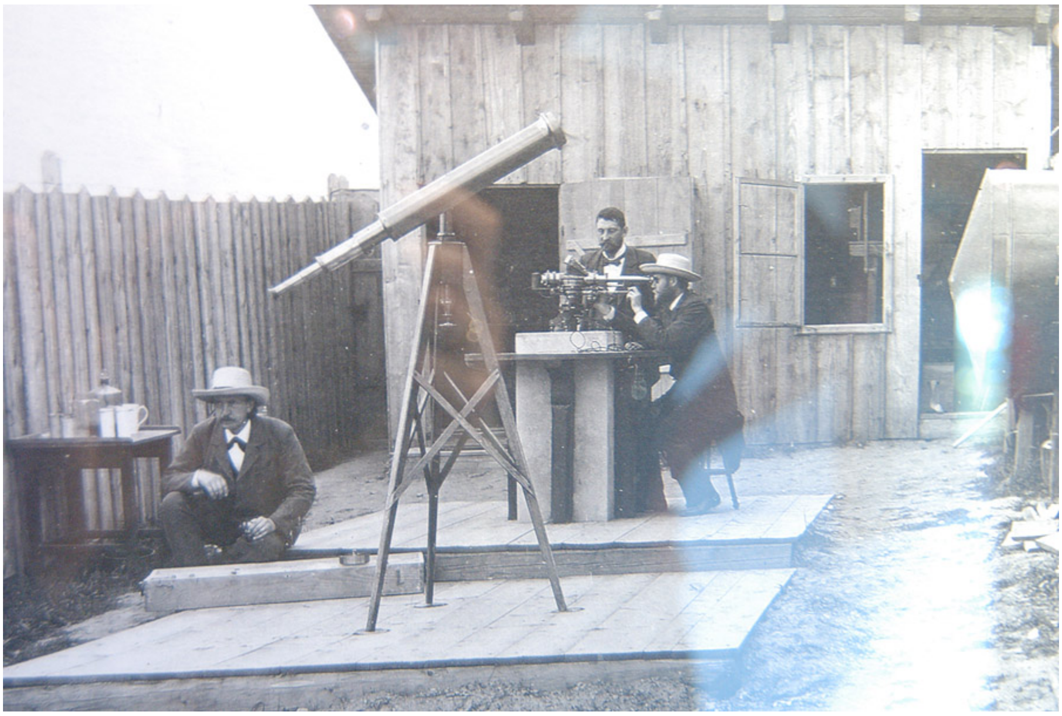
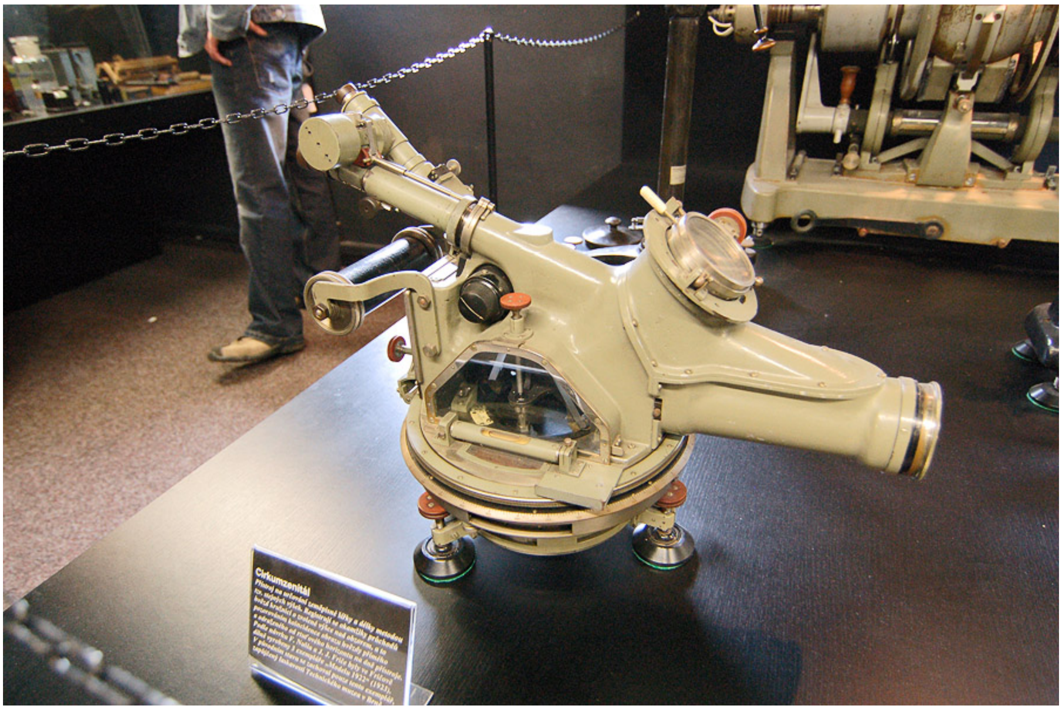
Sjezd geodetické a geofyzikální unie - 19

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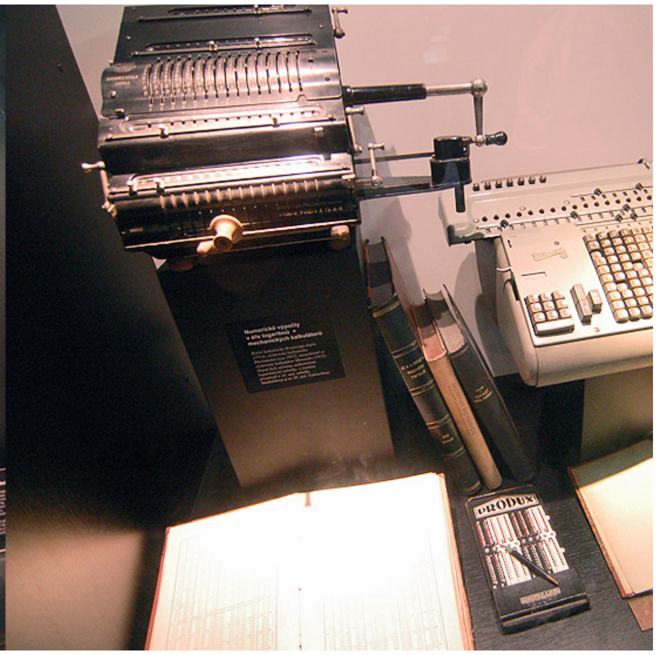
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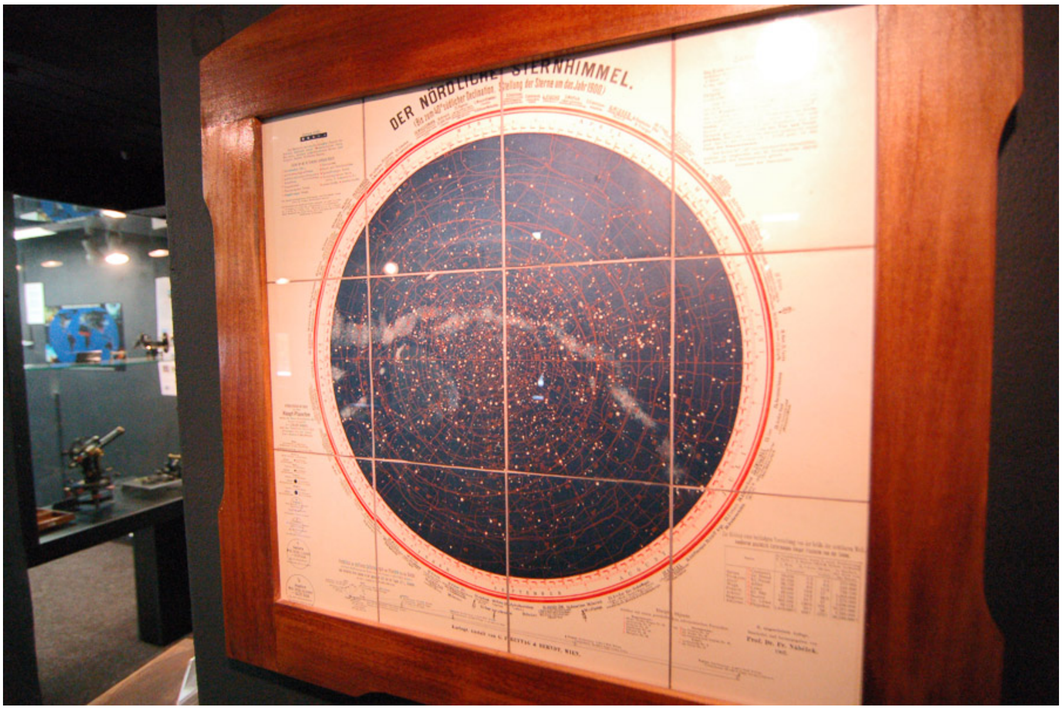
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