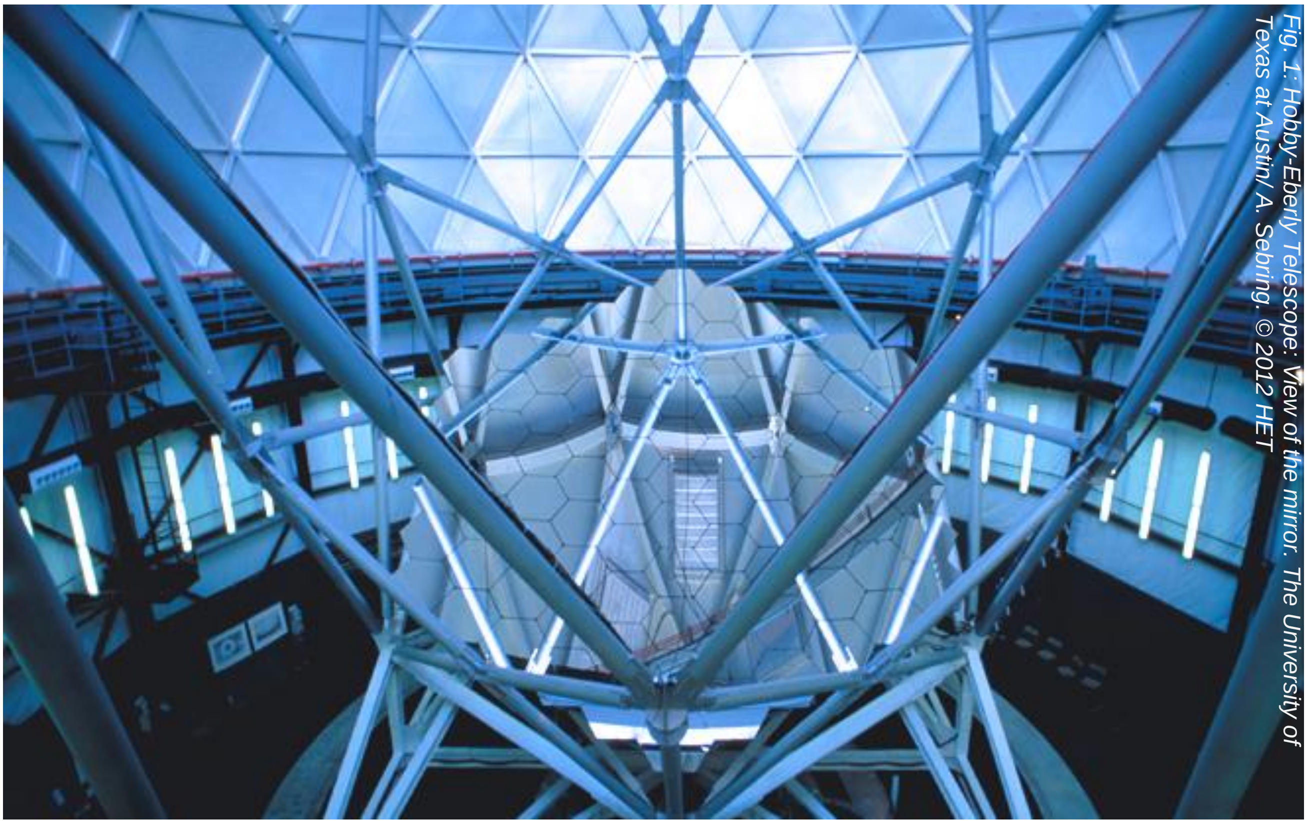

Fig. 1: Hobby-Eberly Telescope: View of the mirror. The University of Texas at Austin/ A. Sebring. © 2012 HET

The dark energy of the universe.

The HETDEX project is the first major attempt to find "dark energy" in the universe. With special spectrographs, the three-dimensional positions of one million galaxies are recorded. In the summer of 2012, the Hobby-Eberly Telescope will start scanning the universe – aided by maxon motors every step of the way.

The Hobby-Eberly Telescope (HET) is located at the McDonald Observatory in West Texas. Its spherical primary mirror consists of 91 identical hexagonal segments, each one meter in size. Together, these individual mirror segments form a mirror with a diameter of almost 11 m, which makes it the largest in the world. The effective aperture of the primary mirror currently amounts to 9.2 m at an opening angle of four arc minutes*. With its 11.1 m by 9.8 m, the HET is the fourth-largest optical telescope in the world. Furthermore, thanks to its innovative design, it was produced very cost-effectively: It only cost 13.5 million dollars – approx. a quarter of the cost of a comparably large telescope. These savings were made possible partly by simplifying the design and by using commercially available components.

The spectroscopic telescope for observation of the skies is mounted on a so-called Prime Focus Instrument Package (PFIP). It is equipped with two spectrographs with medium and high resolution. Even more savings have been achieved by forfeiting moving the 85-ton telescope around the second axis. That means that the mirror always looks at a position 55 degrees above the horizon, but simultaneously can be swiveled horizontally full circle. This makes it possible to observe 70 percent of the skies. The light gathered by the primary mirror is bundled above the primary mirror, where it is received by a special auxiliary lens and transmitted to the spectrographs via optical fiber. This auxiliary lens is mounted in the so-called "tracker" (see figure 3), which offers movement in 6 axes. The mirror thus does not follow the object; instead the object moves over the circle.

Currently, the wide field components of the HET are being upgraded to increase the angle of view to 22 arc minutes and the usable aperture to 10 meters. In future research projects, these upgrades will make it possible to gather the highest possible light quantity by means of a glass fiber coupling and thus revolutionize spectroscopic observations. Scientists want to use the new, upgraded HET to obtain a better understanding of so-called "dark energy". According to the current hypotheses, almost three quarters of matter and energy in the universe consists of "dark energy", and it is considered to be a mysterious force that causes the universe to drift apart at an increasing speed as it gets older.

HETDEX looks at the universe

The HETDEX project (Hobby-Eberly Telescope Dark Energy Experiment) was initiated to solve this mystery. From 2012 to 2015, the section of the sky containing the Big Dipper constellation will be scanned intensively with the HET. The research project aims to map 1 million galaxies that are 10 to 11 billion light years from earth – down to the smallest detail. The project is the result of the cooperation between the University of Texas (Austin), the Pennsylvania State University, the Texas A&M University, the University Observatory Munich, the Leibniz Institute for Astrophysics in Potsdam and the Max Planck Institute for Extraterrestrial Physics.

International scientists want to know more about the processes that occur in the universe. The purpose of the large-scale research project is to verify whether the current laws of gravity are correct. Another aim is to discover new astronomic details about the Big Bang. At the observatory on Mount Fowlkes in Texas, the light in the HETDEX camera is not captured by a photo chip, but instead by 33,400 glass fibers. The experts hope that, instead of dark matter, other hitherto unknown gravity effects are causing our cosmos to expand. The first evidence for one of the theses about dark matter – or an answer that conclusively proves a certain phenomenon to be non-existent – is expected for 2016 at the earliest.

Design of the PFIP

The Prime Focus Instrument Package is is positioned on a tracking device at the top of the telescope and is equipped with a wide field corrector, a capturing camera, measuring devices and a focal plane system. The PFIP is a a standalone automation unit with 12 subsystems and 24 movement axes. Motion controllers and modular I/O systems are connected using the CANopen messaging protocol. All communication between the ground-level systems and the PFIP subsystems are conducted either point-to-point via Ethernet, or through Ethernet/CAN gateways that pass CANopen messages transparently.

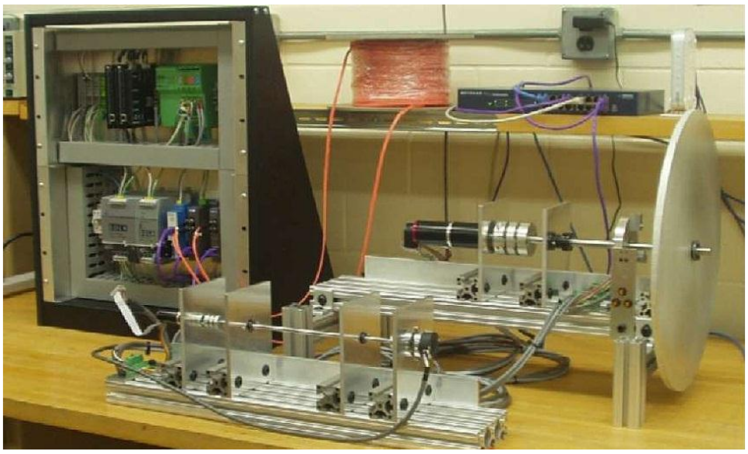

Figure 2: This multi-axis test bench is used to test the electronics and software of the PFIP controller. The mechanical assembly on the right contains the maxon motors, position encoders, limit switches and inertial loads that are used to simulate the various PFIP mechanisms. © 2012 HET

The PFIP has 24 motion axes, 15 of which are motorized. The movements have to be executed smoothly and with high precision at various speeds, in particular at extremely slow speeds. The motion controller has to be able to perform several operations in different situations, for example accurately following a velocity curve (aperture control), moving to and holding an absolute position, or following a multi-axial position and velocity curve.

The drives used in the PFIP subsystems are maxon motors of the brushless EC series, which can be equipped with gearheads, magnetic incremental encoders, and electrically operated brakes as required. Smooth motion at low speeds is achieved by means of sinusoidal commutation. Therefore, in addition to the standard Hall sensors installed in the brushless maxon motors, an optional incremental encoder is used. Incremental encoders provide additional position data to the motion controller.

Accurate maxon positioning control units

All controllers are maxon positioning control units of type EPOS2 50/5. In addition to the closed-loop control circuits for current, velocity and position, the controllers have an interpolated motion mode that enables them to follow a programmed multi-axis trajectory. Furthermore, the EPOS2 is equipped with analog and digital input and output devices that can be accessed via the CANopen interface. It is also possible to program reactions to digital input signals, such as positive/negative limit values, home position, quick stop and drive activation/deactivation. In the PFIP application, the modular I/O stations have CANopen bus couplers,which make it possible to communicate with all additional I/O devices directly via the CAN bus or via an Ethernet-based CAN gateway. The gateway uses a simple ASCII protocol for configuration and for sending messages in both directions.

In this application, hardware devices are connected to the CAN bus and are controlled by the PFIP computer (PCC) in a master/slave configuration. In the event of multi-axis motion, the PCC would for example configure several motion controllers for the desired motion and trigger them simultaneously by means of a single CANopen command. The PFIP motion controller generally uses a 24 V DC supply. For higher inertial loads, such as the shutter, a 48 V supply can be used and is compatible to the EPOS2 50/5 controllers. Compliance with the specifications for PFIP and HET requires that all hardware components also function at temperatures of -10°C or below. maxon motor offers a wide range of products that meet these temperature requirements and provide the quality, reliability and ruggedness required for industrial automation systems.

All in all, the architecture of the HET is very flexible. By adding or removing motion controllers, I/O modules or voltage supplies, significant changes can be made very easily. The components are small and light enough to allow space in the initial design for later add-ons and supplements.

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Application note: 7720 characters, 1222 words, 4 figures

*The arc minute is a unit for specifying the size of angles in degrees. Just like the time units of hours, minutes and seconds, the sexagesimal system is used to measure angles in degrees. One angular degree therefore consists of 60 arc minutes and an arc minute consists of 60 arc seconds. An arc minute thus equals 1/60 of one degree and is a measurement unit for the angular distance between two objects. (Source: www.wissenschaft-online.de; http://www.astronomie.de)

Sources/links:

http://www.usm.uni-muenchen.de

http://www.as.utexas.edu/mcdonald/het/het.html

http://hetdex.org/

Figure 3: The Hobby-Eberly Telescope (left) with its dome open. On the right is a close-up of the HET with the primary mirror and telescope structure, incl. the tracker that supports the PFIP. © 2012 HET

Figure 4: This photo shows the EC motor family and the control units that maxon use for industrial applications, such as the HETDEX project. © 2012 maxon motor

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