The Astrophotography Mount

What is a Mount?

The mount provides for the smooth and controlled movement of the Telescope pointing around the sky. The mount together with its base supporting the telescope firmly so astronomical objects can be viewed or imaged without being disturbed by movement or vibration.

A Mount sits on some form of a stable solid base such as a Tripod and should function as an immovable base. To increase its rigidness, the tripod should sit firmly on the ground with its legs adjusted low, so the centre of gravity is close to the ground.

The mount is the most important component of the Astronomical Imaging System and should be the component with the highest quality.

The preferred type of Mount for Astrophotography

The ideal type of Mount for amateur Astrophotography is a motorised **Equatorial Mount**, (sometimes also called a Polar Mount). Motorised versions of mount keep the telescope moving at a constant rate across the sky as the earth rotates around its polar axis, an imaginary line from the South to the North poles through the centre of the Earth.

An unmotorised equatorial mount will not keep the telescope moving at the constant rate needed for astrophotography. Without a computer-controlled motor on the mount precisely turning the Telescope around the polar axis, a user would need to adjust the mount's polar adjustment knob constantly to keep the image near the centre of the Field of View (FOV) of the Telescope. Also, the camera cannot be exposed while the mount is being manually rotated so the camera's exposure time would need to be limited to the '500 rule' calculation to prevent the blurring of stars in the photo. So for Deep Sky images needing using a focal length greater than about 20mm, a motorised mount is needed.

The Mount rotates the Telescope around its polar axis, but in the opposite direction to the Earth's rotation on its axis. The Telescope's polar axis is aligned to the Earth's polar axis in a process called Polar Alignment.

The east to west movement of the Telescope across the sky is at the same rate as the earth's west to east rotation (called the Sidereal rate).

The two opposite rotational movements keep the Telescope pointing to the same place in the sky so that the image being projected onto the sensor of the camera attached to the Telescope doesn't move during the Camera's exposure time.

The Equatorial Mount

A motorised equatorial mount will move the Telescope across the sky at the same rate as the earth is turning but in the opposite direction. This rate is the Sidereal rate and is defined as the rate that stars appear to move across the sky at the equator. It is about 360 degrees every 23.9344696 hours (or about 23 hours, 56 minutes, 4.0905 seconds)

So, in summary, an Equatorial Mount is aligned with the Earth's polar axis, rotates in an east to west direction, at the Sidereal rate, so moves the Telescope and camera, at the same rate as the movement of the deep sky objects across the sky.

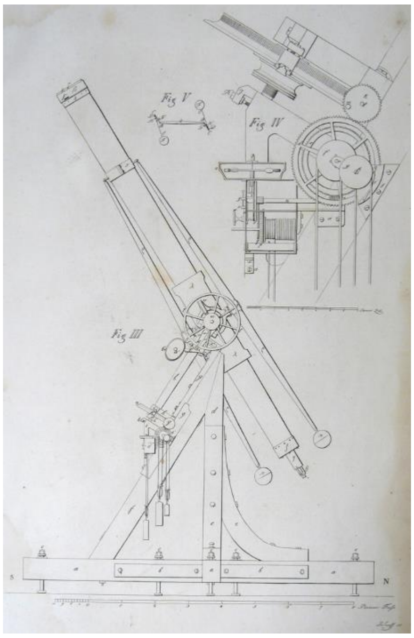
The **German Equatorial Mount** (or GEM) is the most popular equatorial mount used by Astrophotographers. Other types of Equatorial mounts also exist with some examples being the Open Fork mount, Springfield mount, English or Yoke mount, Horseshoe mount, Cross-axis mount and Scotch mount (or Barn door tracker).

The German Equatorial Mount

The origins of the GEM

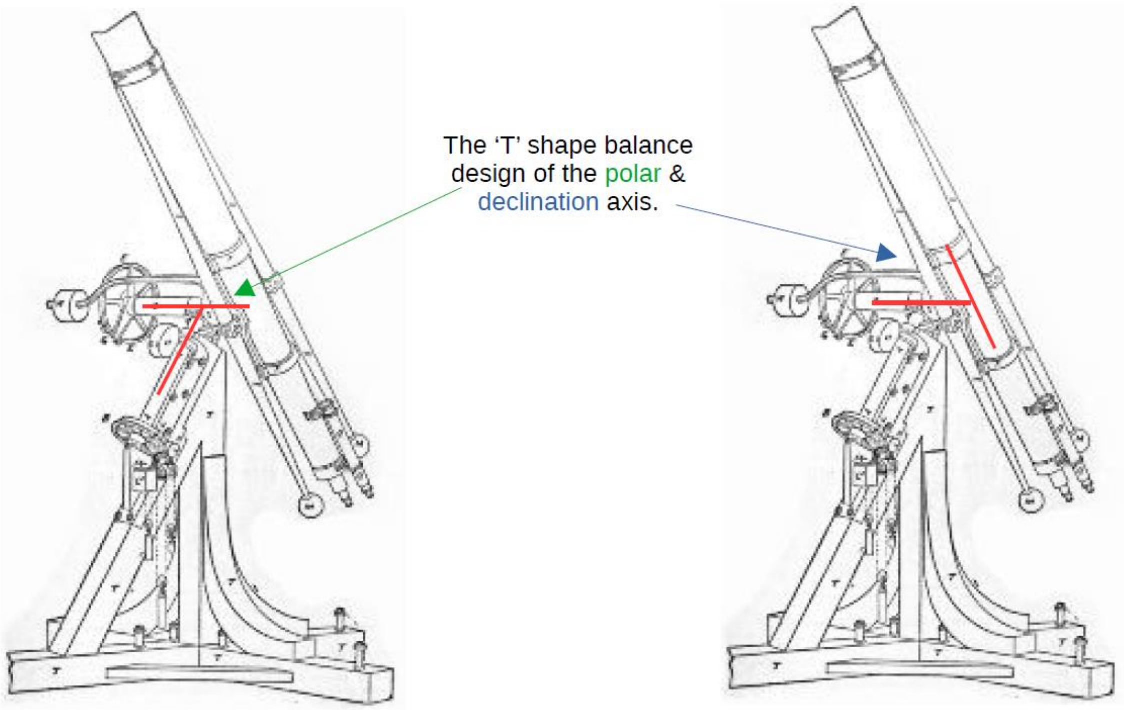
In 1813, Joseph von Fraunhofer, a physicist and optician from Straubing in southern Germany, needed a Mount for his telescope project at the Dorpat Observatory in Russia (now Tartouo, Estonia).

The Telescope was to be a 245mm refractor telescope with a focal length of 4.1m. The lens he made in 1819 was the largest at that time and the Telescope was installed at the Dorpat Observatory by 1824.

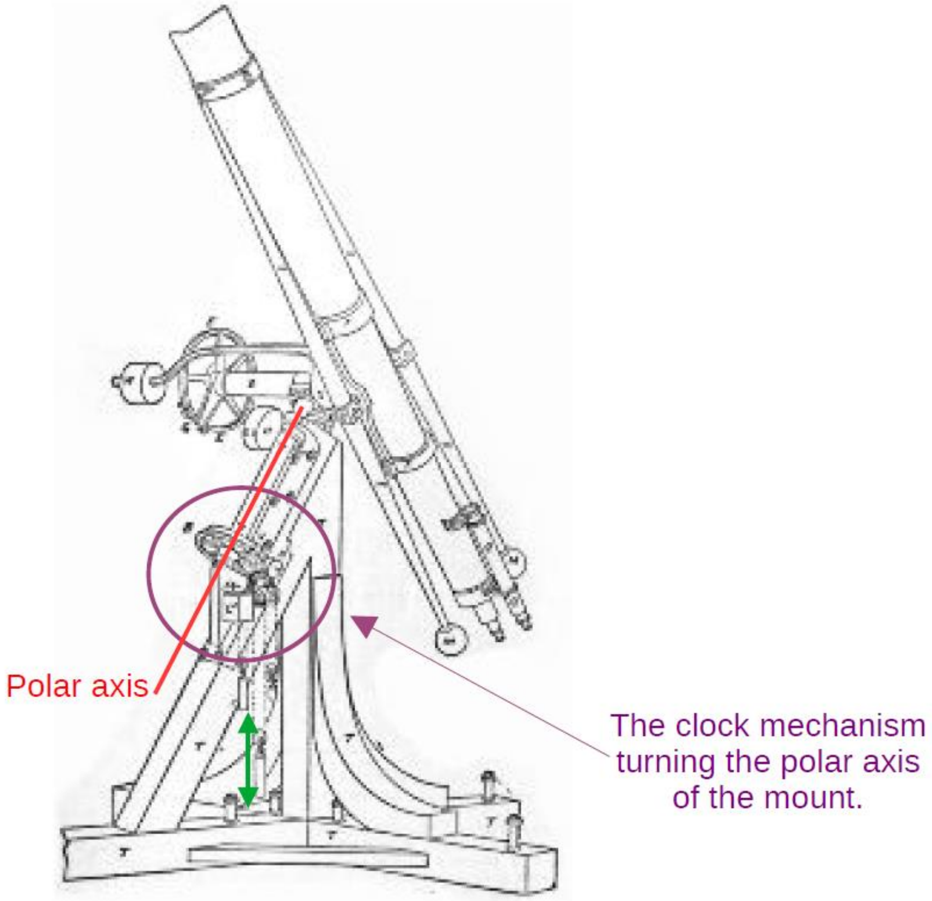


His mount design was the first of its kind and later came to be known as the German Equatorial Mount (or GEM).

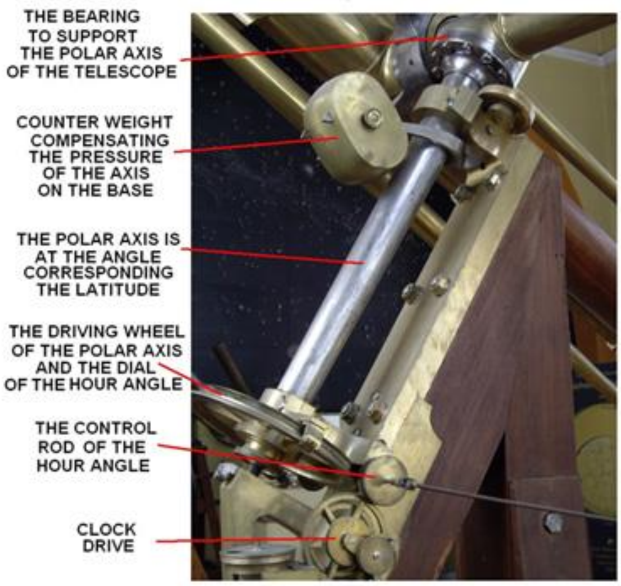
The basic design was around the shape of a ‘T’. The vertical axis of the ‘T’ is aligned with the polar axis of the earth, the Telescope is attached to one side of the horizontal arm of the ‘T’ and balancing weight on the opposite side of the horizontal arm of the ‘T’.

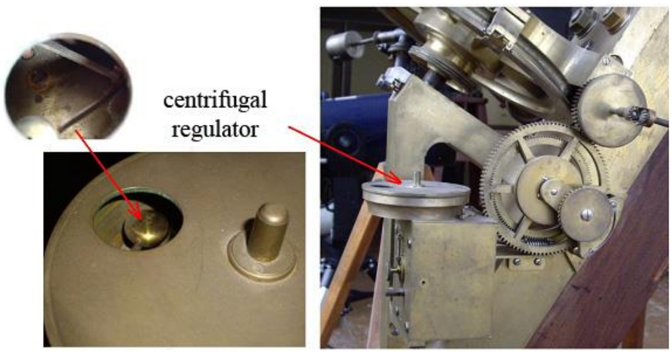


The mount's design of the balance of the Telescope on one side of the 'T' and a weight on the other side, enabled it to be driven by a clock mechanism. The mount's drive was the first in the world to automatically track objects in the sky.



The design enabled the Telescope to be rotated around the polar axis with very little effort. The clock weights that were set before the observing run, the drive rotation rate controlled by a centrifugal regulator, was adjusted and set to keep the objects being viewed in the sky, centred in the eyepiece.

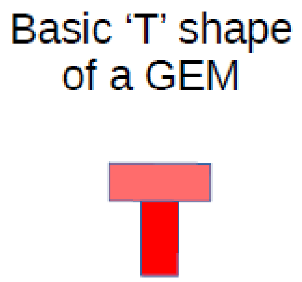


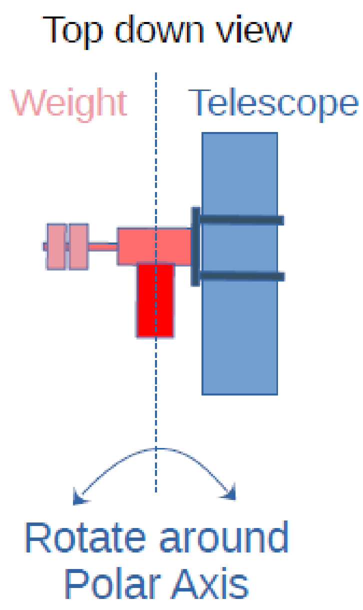


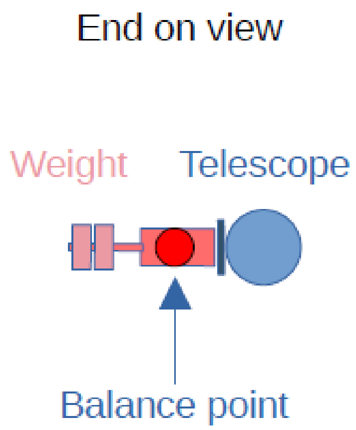
German Equatorial Mount (GEM) overview.

Starting with Fraunhofer's 'T' design discussed earlier and applying it to today's mounts, the balanced 'T' enables the use of low torque motors in an equatorial mount replacing the clock mechanism of yesteryear. The manufacturers of amateur Astro imager have been able to leverage off this design.

The following diagram shows how the Telescope is balanced with weights on the polar axis to allow a small motor to rotate the Telescope around the polar axis. The weights are slid along the bar to vary the rotational force on the balanced system.

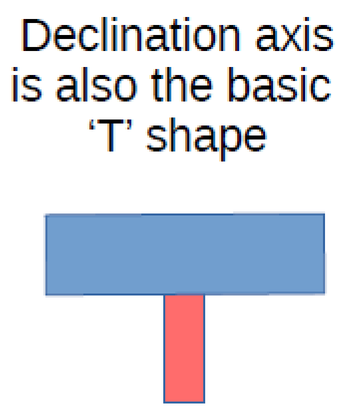


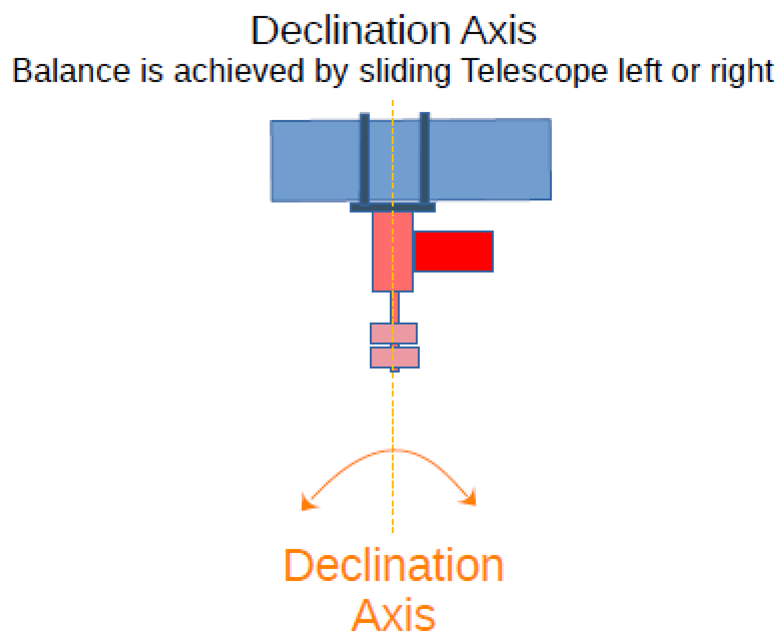




Rotating the Telescope around the Polar (or Equatorial) axis that is aligned with the celestial pole is the basic requirement of the Equatorial Mount. The position along the Equatorial axis is called the Right Ascension (or RA)

The Declination axis tilts the Telescope in a South to North line away from the celestial pole. If you can imagine your object moving across the sky, rotating in a circle around the celestial pole, then picture a baseline from your mount to the celestial pole, and another line to that imaginary circle, then the declination angle is the angle from baseline the other line to that imaginary circle around celestial the pole.

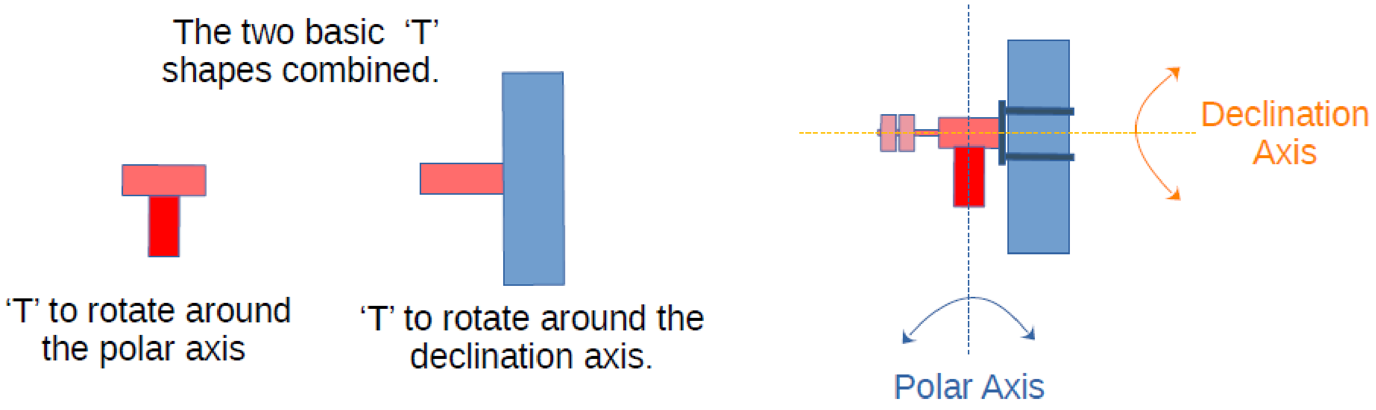




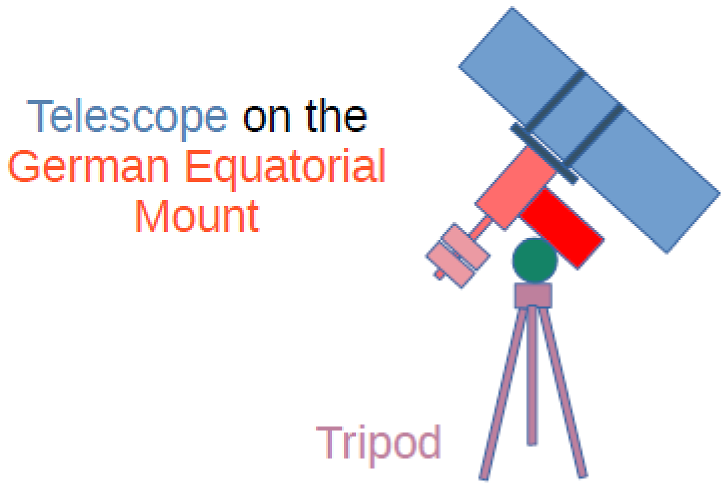
Balancing the declination axis is achieved not by moving weights as done in the polar axis, but by moving the Telescope mounting point to the mount until it's balanced.

By combining the two equatorial and declination movement axes into one system, the Telescope can be pointed to an object across the sky. Once the Telescope is pointed to a place in the sky, just the movement of the polar access is needed to keep the image of the sky as viewed by the camera, still in the Telescope.

If the mount is not precisely aligned to the celestial pole, then it will not trace a perfect circle around the pole so the declination angle may need slight adjustment using a computer application to adjust the motor in a motorised mount. The process of constantly monitoring the star movement around the celestial pole is called Guiding.



The German Equatorial Mount (or GEM) is a popular, cost-effective design choice used by amateur imagers for an equatorial mount. The following information is more applicable to the German Equatorial.



Altitude - Azimuth Mount

While equatorial mounts are the preferred mount type for the amateur imager, other types of mounts exist such as the Altitude-Altitude mount, Transit mount, Zenith mount, Hexapod telescope, Infinite-axis telescope (Trackball or Bolling Ball mount) and Altitude-Azimuth mount. The Altitude-Azimuth mount (or Alt-Az mount) is commonly used by amateur visual observers and very large professional telescopes.

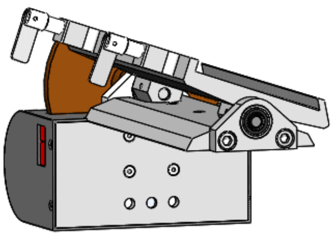
The Alt-Az mount is easier to point in the sky as its movements are up/down (i.e., Altitude) and left/right (i.e., Azimuth). The imaging drawback with an Alt-Az mount is that it doesn't rotate with the sky, and imaging straight up at the sky (i.e., pointing to the Zenith) has issues (issues solved with the Altitude-Altitude mount).

Using the Alt-Az mount for visual observation, your eyes can adjust for movement and follow the sky slowly rotating as you observe an object. If the Alt-Az mount is used for imaging, the camera attached to the telescope does not rotate as the sky rotates. This can result in stars in the middle of the image not smeared but as you look towards the edge of the image, stars will be more elongated the closer you look to the edges of the image (the amount of smear depending on the sensor size and exposure length). This is due to the camera's view being rotated as the sensor is being exposed which causes the streaks around the edges. This is called field rotation. Note that field rotation does not refer to multiple images taken over time that appear to be rotated being at different angles in the sky. These images can be aligned (including rotated) during normal image processing.

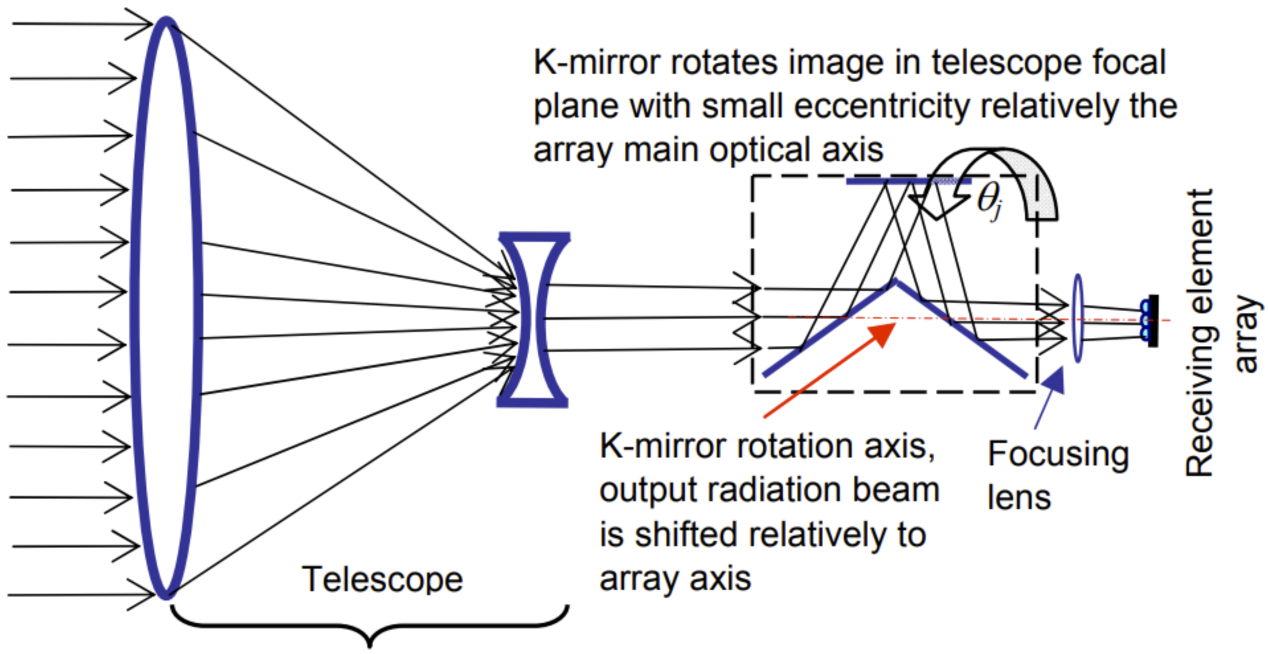
Constructing a very large Equatorial Mount becomes impractical when they are the size of a large multi-storey building. The complexity of dealing with field rotation becomes simpler than rotating building-sized telescopes.

Field Derotation for an Alt-Az Mount

Field derotation for a Telescope's imaging train can be expensive and complicated, which is why it's not widely used in the small setups used by amateur imagers. A field derotator may be employed on an Alt-Az mount to rotate the whole telescope, with the camera attached, in the opposite direction to the sky. Depending on the design of the derotator, they often need resetting every so often. An example of a derotator is the Trackthestars rOTAtor https://trackthestars.com/product/telescope-rotator/ It is secured to the mount and the whole telescope is mounted to it. It needs resetting after 1 to 3 hours the depending on how high the Telescope is pointing in the sky.



Very large professional Telescopes can use a rotating K-Mirror to derotate the beam of light from the sky coming out of the telescope assembly before the image is captured on the camera sensor.



Ref: [Image reconstruction with sub-diffraction resolution in radio vision devices of millimetre and terahertz range using receiving arrays and image scanning]

An Astro camera rotator normally used to frame an object on an Equatorial Mount can also be used as a camera derotator on an Alt-Az mount. Normally, a camera rotator is used to rotate the camera on an Equatorial mount to assist in getting predictable and automatic framing of the camera to the sky. Various manufacturers have the derotator option in their software supplied with a rotator. This derotation method does not rotate the optical assembly so loses the ability to correct for any intensity variations caused by dust, vignetting or other optical imperfections in the imaging path. The imperfections cannot be corrected using flats, as the imaging path is constantly changing as the camera rotates but the Telescope doesn't.