Physical Sciences

Aligning Astronomical Telescopes via Identification of Stars

The alignment process would be completely automatic.

Marshall Space Flight Center, Alabama

A proposed method of automated, precise alignment of a ground-based astronomical telescope would eliminate the need for initial manual alignment. The method, based on automated identification of known stars and other celestial objects in the telescope field of view, would also eliminate the need for an initial estimate of the aiming direction. The method does not require any equipment other than a digital imaging device such as a charge-coupled-device digital imaging camera and control computers of the telescope and camera, all of which are standard components in professional astronomical telescope systems and in high-end amateur astronomical telescope systems. The method could be implemented in software running in the telescope or camera control computer or in an external computer communicating with the telescope pointing mount and camera control computers.

The image in the telescope field of view would be captured by the digital imaging device and digitized and then, according to the method, would be processed by a variant of any of several previously published star-identification algorithms. In simplified terms, such an algorithm determines criteria such as brightnesses and relative angles or distances between stars in the digital image and matches those criteria with stars in a database. Once such a match was found, the celestial coordinates of the identified objects in the image and the pixel coordinates of the object would be used to precisely determine the line of sight of the telescope in celestial coordinates.

Although the method does not require an initial estimate of the aiming direction, such an estimate (or ancillary information from which such an estimate can be calculated) could be used to accelerate the automated precise alignment process by limiting the search space to a small portion of the celestial-object database. Even if all that is known are the geographic coordinates of the telescope and the time, portions of the sky known not to be visible from that location at that time could be excluded from the search.

Once the celestial coordinates of two different lines of sight have been determined precisely as outlined above, the telescope would be automatically initialized and aligned for subsequent automated pointing and tracking. Thereafter, during tracking, the alignment process as described thus far could be repeated as often as desired to update the alignment: At each update, the celestial coordinates of the current line of sight would be communicated to the telescope control computer to maintain or restore the precise alignment of the telescope drive axes. Because the line-of-sight directions determined by this method would be based on direct observation of celestial objects having known coordinates, they would be more accurate than are the line-of-sight directions determined by prior methods that involve intermediate measurements (e.g., drive-shaft-angle measurements), which introduce drive-train and axis-misalignment errors.

This work was done by Mark Whorton of Marshall Space Flight Center.

This invention is owned by NASA, and a patent application has been filed. For further information, contact Sammy Nabors, MSFC Commercialization Assistance Lead, at sammy.a.nabors@nasa.gov. Refer to MFS-31968-1.

Generation of Optical Combs in a WGM Resonator From a Bichromatic Pump

A different approach to nonlinear oscillation excitation avoids undesired effects that previously limited optical comb quality.

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Optical combs generated by a monolithic resonator with Kerr-medium can be used in a number of applications, including orbital clocks and frequency standards of extremely high accuracy, such as astronomy, molecular spectroscopy, and the like. The main difficulty of this approach is the relatively high pump power that has to be used in such devices, causing undesired thermorefractive effects, as well as stimulated Raman scattering, and limiting the optical comb quality and utility.

In order to overcome this problem, this innovation uses a different approach to excitation of the nonlinear oscillations in a Kerr-nonlinear whispering gallery mode (WGM) resonator and generation of the optical comb. By coupling to the resonator two optical pump frequencies instead of just one, the efficiency of the comb source can be increased considerably. It therefore can operate in a lower-power regime where the undesirable effects are not present. This process does not have a power threshold; therefore, the new optical component can easily be made strong enough to generate further components, making the optical comb spread in a cascade fashion. Additionally, the comb spacing can be made in an arbitrary number of the resonator free spectral ranges (FSR).

The experimental setup for this innovation used a fluorite resonator with