RYCHLÝ DALEKOHLED PRO DETEKCI DOSVITU GAMA ZÁBLESKŮ

A Project of a Fast Telescope for the Detection of Gamma-ray Bursts Afterglow

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Abstract: Various types of telescopes are used for the detection of gamma ray bursts afterglow and the following spectral analysis. The gamma burst duration is as short as a second, up to hundreds of seconds. An afterglow can be observed 24 hours after the burst even. The intensity of the afterglow drops rapidly though. Therefore it is essential to start the observing as soon as possible. Gamma ray sources are localized by satellites and data are distributed via GCN network to terrestrial telescopes. A fast and rigid mounting for the terrestrial telescope is needed, with an ability to observe a target at any point of nearly the whole hemisphere.

Key words: gamma ray burst, afterglow, fast telescope, mounting, Cardan joint, mosaic mirror

1. Introduction

The astronomy of high energies is a comparatively new astronomic subject, which is based on a fundamental possibility of gamma-ray bursts detection by specialised satellites. These phenomena are allied to a release of an extra amount of energy. Despite the sources are most probably extra galactic, the radiated energy is so high that these sources are detectable in “our” part of space as well.

The direct detection of the bursts is founded on a satellite observation. The burst is short (approx. 10^2 s) though and the bearings of the source are not very accurate (10^1 arc minutes). The emission of energy has a response in visible part of electromagnetic spectrum too and thanks to this it can be detected by terrestrial optical instruments. Taking into account the short time available and the uncertainty in position, a special type of telescope is needed.

As results from what we mentioned above, a telescope intended for observation of afterglow must fulfil at least following conditions

- it can be quickly set to a direction needed
- the setting must be automatic according to data coming via internet

- it must have a high aperture ratio and a comparatively large field of view
- the telescope mounting must achieve nearly the whole half-space (approx. starting at 10° above horizon) without mechanical singularities

2. Concept

Optical design

An interesting possibility seems to be a design of mosaic monolith primary mirror (brought in by A. B. Meinel & col.). The polished faceplate is a thin shell attached to a monolithic substrate (using vacuum pads). The advantages of this solution are following

- the primary mirror is lightweight
- less amount of an expensive optical glass is needed
- a stiffness of the substrate is sufficient
- the mirror can be removed for realuminizing if needed

The diameter of the primary will be about 600mm and the f-ratio approx. 1.5. The diameter of the primary of 250mm would allow the detection down to 18th magnitude.

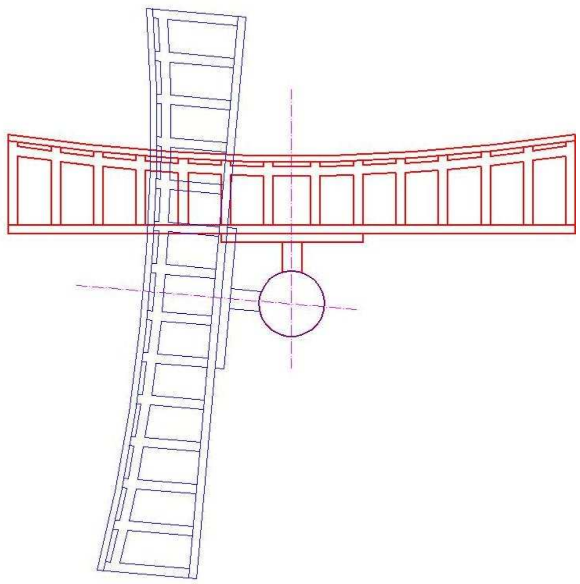

Fig. 1: The concept of the telescope – substrate of the primary

Mounting

Mechatronics is quite a new field with excellent applications in mechanical engineering (manipulators, robots, machine-tools) and in instrument engineering (positioning tools). Mechatronics unites mechanical systems with information technology. Its applications are often based on parallel kinematic structures that are statically over determined. Difficulties connected to this fact are surmounted just by application of IT.

Systems based on parallel kinematics were tested in the past for astronomical applications; especially it was a famous Hexapod. Its drawback is though a scant tilt range, which is about ± 40°. For higher inclinations, the system comes in on the singularity range what induces a raise of forces in struts and eventually a collapse of the entire system.

The Hexasphere mechanism was developed at Department of Mechanics, Biomechanics and Mechatronics. The kinematic qualification was proved at a functional prototype. In contrast to Hexapod, this system has got a steady abutment with a spherical joint which lessens the number of degrees of freedom of all the three traverses, but it allows a tilt of the platform in a range at least ± 120°.

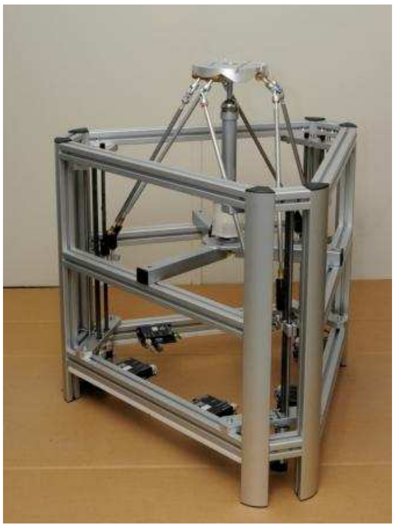

Fig. 2: The kinematic model

Fig. 3: The platform

The mounting of a telescope based on Hexasphere system brings for the given application the elementary benefit that it can pass from one point at a sphere to another along orthodroma (i.e. the shortest way) and the fastest way without going through any singularity as it is when a telescope on azimuth mounting goes through zenith. A tilt range of ±85° is sufficient for a meaningful application. This can be solved without serious problems.

It must be said for sequent designing work that the crucial part of parallel structures are the abutments. Their stiffness, stability and a traverse free of slackness are fundamental parameters for achieving an accurate positioning and reproducibility of settings. For achieving a high dynamic it is needed to minimize inertial effects of both structural members and optical part of the instrument.

Other important parts of the system mentioned above are general-purpose joints mostly designed similarly to Cardan joint. Their influence to accuracy and reproducibility is at least the same as the one of abutments. Therefore a development of abutments is highly wanting for achieving optimal outcome of the whole structure.

Fig. 4: Cardan joints at the upper (left) and lower ends of abutments (right)

3. Conclusion

The next work will focus on a design of the intrinsic telescope, i.e. its both optical and mechanical parts. Hexasphere will be adapted to a smaller range of angles. The job priority for designing the mechanical part is to achieve the maximum stiffness attached to the minimal mass of the structure.

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