# The Principle of the Technology and Design of the Parabolic Strip Telescope

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**Abstract**— Contribution of this paper is a proposal of the new special type of telescope with a parabolic strip as a primary element for astronomical observations or for measurements with good angular resolution in one direction. The observed objects are displayed as lines in the image plane of a length equal to the width of the mirror strip. If we observe a sufficiently bright object, the observation allows us to distinguish fine detail or fine movements on the sky. Each line segment corresponds to the integral intensity of the incident light from the observed object in the direction perpendicular to the mirror strip. For the reconstruction of the whole image with good resolution we need a parabolic mirror strip to rotate around the optical axis, and a series of sequential snaps with a special camera. Different algorithms for reconstruction of the image are used. The main advantage of this rotating telescope is mechanical and manufacturing technological simplicity and an innovative design. Nothing comparable has yet been made. Currently constructed large telescopes are made up of segments, using adaptive optics, and generally it is technologically challenging. Systems of interfering telescopes are built (the effective diameter of 30 m to the get better resolution. The proposed telescope can be made of a 50-m long tape without any technological problems. We created two prototypes of telescopes: a small one, with a 0.3-m long mirror strip, and a bigger one, with a 1.4-m long mirror strip. Both telescopes are supported by parallactic mountings, and both are equipped with special cameras with optics, electronics, computer with special controlling software, special servo stepper motors fitted with mechanical transmission, construction of lightweight alloys, plastics and composites.

## 1. INTRODUCTION

This new type of a telescope with a parabolic strip fulfilling the function of an objective is the most fundamental modification of a telescope since the time when first patent was granted to the Dutch optician Hans Lippershey, and the times of those who followed in the footsteps of famous scientists such as Galileo Galilea, Johannes Kepler, and Isaac Newton. The first reflector, a telescope using a mirror as an objective, was designed by Isaac Newton who thus solved the problem of a chromatic aberration caused by different refraction indices for different wavelengths of light in an objective lens. Types of telescope constructions:

- Refracting telescopes

A telescope objective contains a lens or a system of lenses. The optical size of an objective is determined by the lens speed, focal length and the maximum possible magnification.

- Reflecting telescopes

The objective of a reflector is a concave spherical primary mirror, which may be parabolic or hyperbolic. The surface area of the mirror determines the lens speed of a telescope. An image of an object is reflected by a secondary mirror and subsequently observed through an eyepiece. In this telescope type, light is reflected by mirrors and so its tube is only half size, and a heavy mirror is located on the side of an observer, not on the external end of a tube as is the case with a refractor objective.

- Combined refraction/reflection systems

A telescope is composed of two or more mirrors and an objective with a system of lenses. Optically, the secondary mirror is located in front of the primary mirror. Thus, light rays are first reflected from the primary mirror into the secondary mirror, falling on the lens system of an objective. Therefore, these telescopes usually have smaller diameters and their lens speed is also smaller.

Figure 1: A new type of a parabolic strip telescope.

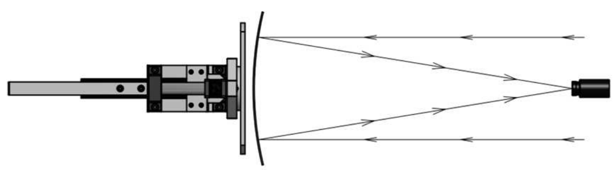

Figure 2: The diagram of a parabolic strip telescope.

### 1.1. The Principle of a Parabolic Strip Telescope

Observed objects are displayed as line segments in the image plane. Every line segment the length of which equals to the width of a strip corresponds to the integral intensity of the incident light falling from the observed objects in the direction perpendicular to a parabolic strip. Through subsequent rotation of the whole telescope or just its strip around the optical axis (the axis perpendicular to the strip centre in the apex of a parabola) and application of the Radon inversion transformation, we may reconstruct the image of an observed object with a good resolving power. It is also possible to reconstruct an image from one snap without any rotation; in this case the angular resolution in the two mutually perpendicular directions will be of different orders. This fact can be utilized for example for the observing of fine movements of brighter objects in the direction of travel. Software processing reconstructs an image according to specific needs and possibilities to make use of the properties of a telescope.

## 2. THE CONSTRUCTION PRINCIPLES FOR A PARABOLIC STRIP TELESCOPE

A distinctive feature of the proposed project of a construction of the new type of a telescope with a parabolic strip fulfilling the function of an objective is that it enables observations or astronomical measurements with a good resolving power in one direction and a worse in the perpendicular direction. The angular resolving power is given by the ratio of the wavelength to the length of the projection of a parabolic strip to the plane tangential to the apex of the parabolic stripe. When observing objects that are sufficiently bright, this observation enables to resolve fine details or catch sight of fine movements in this direction. Observed objects are displayed as line segments in the image plane of a length equal to the strip width. Each of the line segments corresponds to the integral intensity of the incident light from the observed objects in the direction perpendicular to the strip. So that the whole image could be reconstructed with the same good resolving power, the whole telescope or just its parabolic strip can be subsequently rotated around the optical axis (the axis perpendicular to the strip centre in the apex of a parabola) while taking a series of snaps, and apply the Radon inversion transformation as in the case of computed tomography. This means that when we have enough incident light (which is determined by the surface area of a strip), we can resolve fine details. A great technological advantage is that it is incomparably cheaper and easier to manufacture a strip than a paraboloid. It is sufficient to manufacture only parabolic holders and a mirror strip made of an elastic material; the tension in the material which a strip is made of will ensure that the shape will be stable and accurate. In addition, the construction is significantly lighter than that of a paraboloid. Nowadays, very big telescopes composed of segments, or systems of interfering telescopes are constructed at exorbitant costs to achieve fine resolution. Among other things, the system designed by us has more mechanical advantages. Thanks to its low price, it would be possible to deploy a system of telescopes with a tilt angle of for example 15° and install them all over the Earth in different terrestrial longitudes so that they would cover the whole sky. The mechanical construction will be simplified, gravitational impacts will be relatively small and the observation possibilities will be multiplied — it is possible to make simultaneous observations in every angle. Deployment on satellites will also be cheaper thanks to a smaller weight. The resolution power of a telescope fitted with a 120-cm long strip should be similar to the resolution power of a parabolic with a diameter of 150 cm.

### 2.1. The Structural Design and Production of a Prototype of a Parabolic Strip Telescope

A parabolic strip telescope is composed of four main parts:

- A multi-axis astronomical stand with an automatic rotation system following the stellar drift
- A fixed static holder of a telescope with a step-by-step actuating mechanism
- A rotating part of a telescope with a parabolic strip and optics
- A control and evaluation unit

Fixed static holder of a telescope with a step-by-step actuating mechanism The static part of a telescope is composed of a load bearing structure (a weldment from aluminium sections) and two locks with bearings. The rotational movement is secured by a step-by-step actuating mechanism with a step of 0.9° and a timing pulley gear with a ratio of gearing of 1/5.

The control unit controlling the movements of the rotating part of a telescope and the control unit of the camera that records a series of snaps are installed on the opposite end of the load-bearing structure.

### 2.2. The Rotating Part of a Telescope with a Parabolic Strip and Optics

The rotating part of a telescope is designed and composed of the following components: the main load-bearing part made of aluminium sections which is machined on a CNC milling machine (4) and a lathe (5). A timing pulley with a shaft made of aluminium alloy is accurately fixed to this main load-bearing structure by means of assembling components. The following most important components of a telescope are located on the opposite side of the main part: A flexible parabolic mirror strip which is inserted between two plexy appliances with an exact slot cut out by a CNC jig wirecutter. The welded solid construction of a camera holder made of aluminium alloy that ensures exact adjusting of the scanning chip of a camera into the focal point of the incidence of the rays reflected from the parabolic mirror strip.

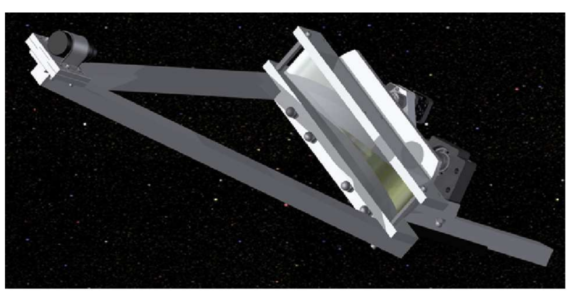

Figure 3: Parabolic strip telescope.

## 3. THE TECHNOLOGY HAS SEVERAL ADVANTAGES

- A good resolution power of a telescope in one direction.
- The manufacturing is many times cheaper than the production of common parabolic strip telescopes.
- Utilization of such a device for example for the tracking of movement and identification of small asteroids in the vicinity of the Earth.

It would be advisable to develop a network of telescopes with a long strip that would be used to monitor the sky and deployed along the meridian according to our proposal (parabolic strips long tens of meters). For objects emitting sufficient light, it may be quite cheap to obtain knowledge

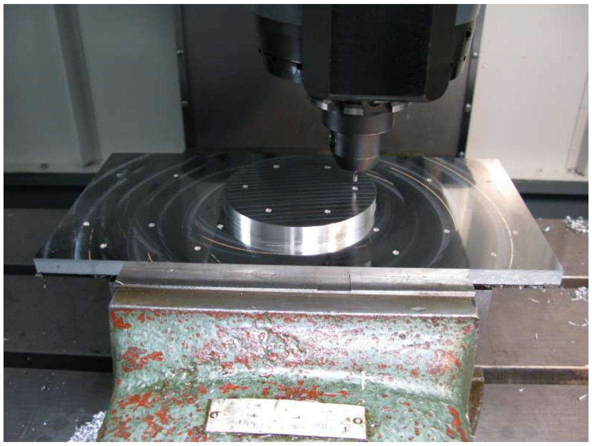

Figure 4: The milling of the surface areas of the main load-bearing part of a telescope.


Figure 5: Lathe-turning of the main load-bearing structure of a telescope.

of minor details. The market seems to be limited only to astronomical observations and remote research of the Earth. Taking into account the technological simplicity and a smaller weight of the telescope, the possibility of its utilization on the Earths orbit and in the cosmic space remains open.

## 4. ADVANTAGES

- high mounting not being necessary,
- low wind influence,
- low gravitational influence.

## ACKNOWLEDGMENT

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