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Active teaching methodologies in the "Science in the Caatinga" project: distinguishing between optical and physically bound double stars

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Abstract. The “Science in the Caatinga” project executes a series of science teaching activities in the Sertão de Itaparica, a semi-arid part of Brazil. Pedagogically based on active teaching methodologies, these activities can be divided into science teaching, science communication and observational practices. In this latter, double stars observations are the main preference, with students measuring angular separation (ρ) and position angle (θ) of the components of the pair. Later, using data of spectral types, trigonometric paralaxes and proper motion vectors of each star, they try to determine whether the components are a line-of-sight optical pair or a physically bound by gravity one. This way, students intuit concepts related to gravitation, such as the Kepler’s Laws, gravitational force and escape velocity. Core objectives of the project are: a) A better understanding of astronomy through a hands-on experience; b) Learn a method for analyzing astronomical data; c) Transform science education through the application of an active teaching methodology. In addition, the project will train selected students to act as multipliers and prepares introductory courses to teachers.

Resumo. O projeto “Ciência na Caatinga” realiza uma série de atividades de ensino de ciências no Sertão de Itaparica, região semiárida do Brasil. Pedagogicamente baseadas em metodologias ativas de ensino, essas atividades podem ser divididas em ensino de ciências, comunicação em ciências e práticas observacionais. Nesta última, as observações de estrelas duplas são a principal preferência, com os estudantes medindo a separação angular (ρ) e o ângulo de posição (θ) dos componentes do par. Posteriormente, usando dados de tipos espectrais, paralaxes trigonométricas e vetores de movimento próprio de cada estrela, eles tentam determinar se os componentes são um par óptico de linha de visão ou um par fisicamente ligado pela gravidade. Dessa forma, os alunos intuem conceitos relacionados à gravitação, como as Leis de Kepler, força gravitacional e velocidade de escape. Os principais objetivos do projeto são: a) Uma melhor compreensão da astronomia por meio de uma experiência prática; b) Aprender um método para analisar dados astronômicos; c) Transformar a educação científica por meio da aplicação de uma metodologia de ensino ativa. Além disso, o projeto capacitará alunos selecionados para atuarem como multiplicadores e preparará cursos introdutórios para professores.

Keywords. Teaching of Astronomy – (Stars:) binaries: visual – Astrometry

1. Introduction

The "Science in the Caatinga" project, through a series of science communication activities and using astronomical bodies as boundary objects, aims to contribute to science teaching in public schools in six cities (Itacuruba, Floresta, Belém do São Francisco, Petrolândia, Jatobá and Tacaratu) in the Itaparica Region, a semi-arid part of the State of Pernambuco, northeast of Brazil. These activities, pedagogically based on the foundations of active teaching methodologies (project-based learning), are divided into three axes: science teaching, science communication and observational practices. In the latter, one of the activities that stands out most in interaction with students is the study of double stars.

A double star is made up of two components relatively close together in the sky. Some doubles are called "optical", since the components are not genuinely associated, but simply happen to lie near the same line of sight as seen from Earth. On the other hand, some doubles are called "binary stars", made up of two components genuinely associated and moving around their common centre of gravity.

2. Methodology

Thus, using a 10-inch (25cm) f/10 SCT with a f/5 focal reducer and a self-made bifilar micrometer, students are involved in measuring the angular separation (ρ) and position angle (θ) of some double star systems (taken from the Washington Double Star Catalog). Later, students referenced the SIMBAD Astronomical Database, using data of spectral types (comparing spectras of both stars), trigonometric parallaxes (to calculate the actual distance to the two stars based on their trigonometric paralaxes) and proper motion vectors of each star of the pair (to determine if they are traveling through space in approximately the same direction), trying to determine if they are a line-of-sight optical pair or physically bound by gravity. After observations, students

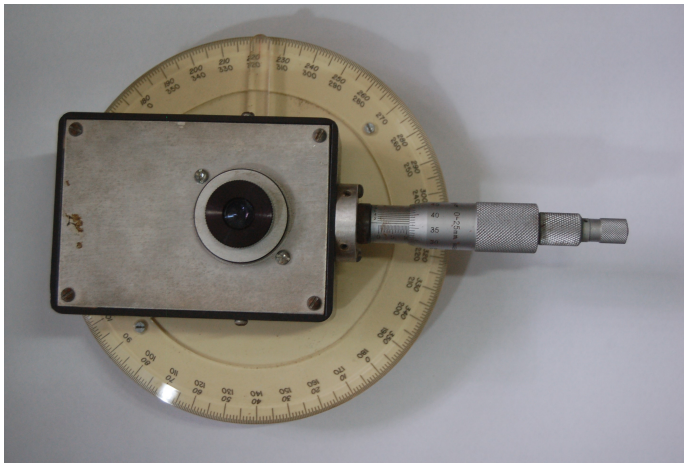

Figure 1. Self-made bifilar micrometer: superior view.

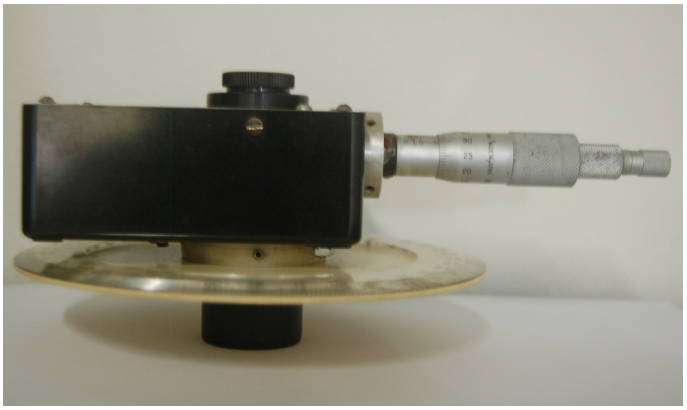

Figure 2. Self-made bifilar micrometer: lateral view.

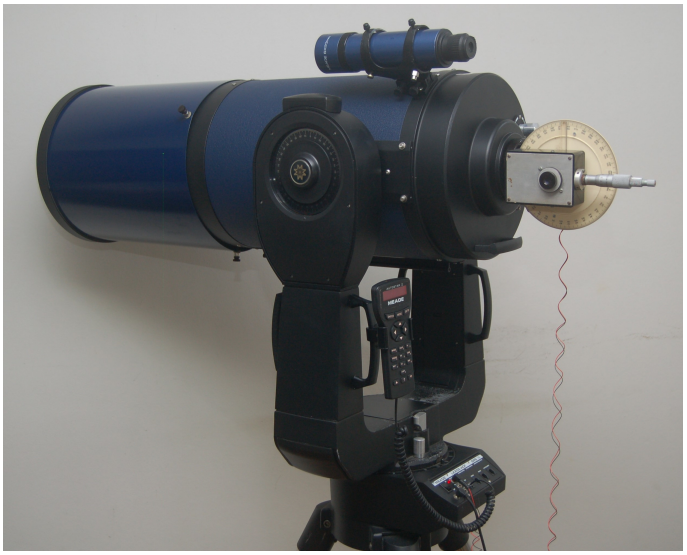

Figure 3. Set: telescope with bifilar micrometer installed.

will be able to analyse and report their results, receiving support and advice from the scientific staff of the project. A variant of this observational proposal would involve capturing digital images (CCD) of the double stars, with subsequent use of astronomical image processing softwares to perform measurements of (ρ, θ) directly from these images. When measuring the angular separation and the position angle of the pair of stars and comparing such measurements with others taken in previous times, students have the opportunity to get insights about the possible gravitational interaction between the components of the pair (or not, if it is an optical pair), which can facilitate the apprehension of some physics concepts related to universal gravitation, such as the Kepler's Laws, gravitational force and escape velocity.

3. Conclusions

The core objectives of this observation activity are: a) To learn and apply a method for measuring double stars, gaining a better understanding of astronomy through a hands-on experience; b) To learn one of the methods for analyzing astronomical data; c) To transform science education through the application of an active teaching methodology (project-based learning). This way, such activities could provide a valuable research tool, but also an inspirational educational opportunity to help motivate students to appreciate physics, mathematics and science better. In addition, the project will train selected students to act as multipliers in their schools, allowing other students to make astronomical observations. Also, a series of introductory courses are now being planned, aimed at showing teachers the current state-of-knowledge of astronomy, training them in the specific skills required to participate in collaborative projects.