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Preliminary Design of the Brazilian's National Institute for Space Research Broadband Radiometer for Solar Observations

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Abstract. The Total Solar Irradiance (TSI), which is the total radiation arriving at Earth's atmosphere from the Sun, is one of the most important forcing of the Earths climate. Measurements of the TSI have been made employing instruments on board several space-based platforms during the last four solar cycles. However, combining these measurements is still challenging due to the degradation of the sensor elements and the long-term stability of the electronics. Here we describe the preliminary efforts to design an absolute radiometer based on the principle of electrical substitution that is under development at Brazilian's National Institute for Space Research (INPE).

Keywords. Total solar irradiance, absolute radiometer, radiometry, absorptive cavities, black Ni-P

1. Introduction

The measurement of the total solar irradiance (TSI) and its variations is very important to understand the influence of the radiation output of the Sun on the Earth's climate. For a better understanding of the importance of these influences upon the Earth's climate, long-term TSI measurements are required. Several instruments aboard space-based platforms have obtained the most reliable observations since around 1978. The records of these instruments overlap in some time periods and differences are observed in the measured values. The Total Irradiance Monitor (TIM) show different values around $4W/m^2$ in relation to others experiments as Variability of Irradiance and Gravity Oscillations Sun PhotoMeter (VIRGO) and Active Cavity Radiometer Irradiance Monitor (ACRIM III) (Kopp *et al.* 2012). The reconstruction of the irradiance based on these observations is challenging due to in-flight degradation of the sensors as well as the different designs and calibration of them. Here we describe the development of an active cavity radiometer by a team at INPE. We describe the preliminary efforts at INPE to build a bench prototype for initial tests and to assist in the characterization of the mechanical, electronic

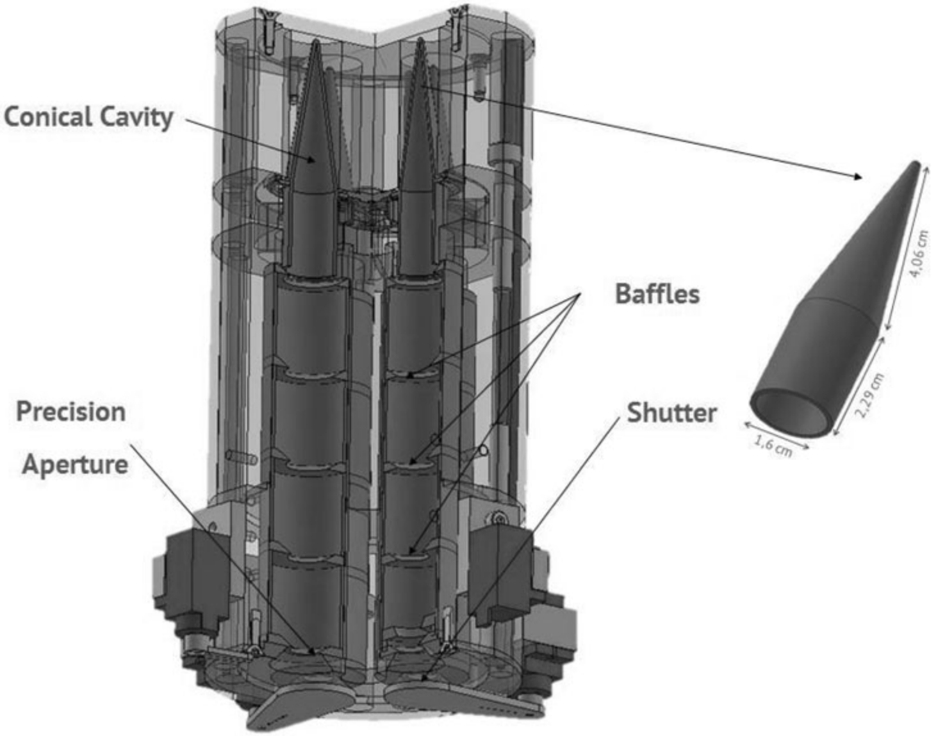

Figure 1. The design of the absolute radiometer broadband to measure the Total Solar Irradiance (TSI).

and optical components. In a second stage, some parts must be tested in an available small satellite. Our main goal is to understand the constraints to design a broadband radiometer to operate on a space-based platform. Additionally, we are aiming to identify incremental improvements in the current design.

2. Overview

The Brazilian Broadband Radiometer is an electrical substitution radiometer. The conceptual design of the instrument is based on existing radiometers, such as TIM instrument on board SORCE spacecraft (Kopp & Lawrence 2005). The device will contain four conical absorptive cavities. The cavities will be made mainly of silver due to the high thermal conductivity and the interior will be coated with a Ni-P film that is highly absorptive and presents excellent thermal conductivity of the substrate of the cone. Three cavities will work in an alternately regime to increase the devices lifetime while the fourth cavity will be kept as a reference. The conical cavities will be maintained at an equilibrium temperature through an electrical current. When the shutter is opened the temperature of cavity will increase due to exposure to solar radiation that depends on parameters system such as thermal link and heat sink (Datla & Parr 2005). Whereas some corrections are needed for final TSI measurement is possible to correlate radiation power and ohmic heating.

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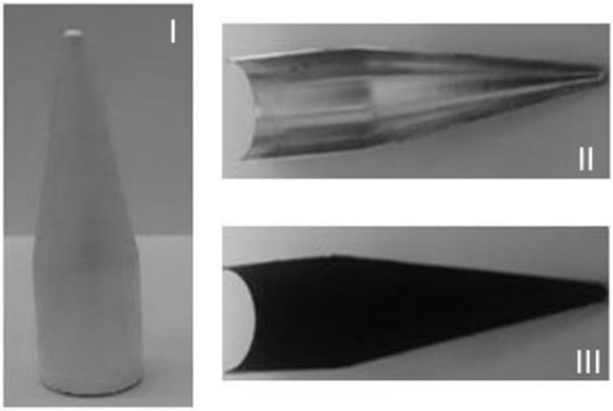

Figure 2. Silver cavity to trap incident sunlight (I) and cavity cross section with Ni-P as deposited (II) and Black Ni-P (III).

3. Concluding Remarks

We are following a formal and structured systems engineering procedure for the development of the broadband radiometer. This approach allows us to define objectively the requirements for the instrument to be developed. Specifically, the systems engineering is being used to develop and manage of the following: definition of the goals, the scope, and the products of the project; identification of constraints, assumptions, risks and dependencies; concept development; technical requirements; definition of the budgets; definition of technical standards; preparation of the documentation to acquire components; performance modeling; verification and validation; and, assembly, integration, testing, and commissioning. As we are developing the system from scratch, we decided to employ a model for the system development lifecycle that describes the activities to be performed and the results that have to be produced during the development. In this initial phase of the project, we are building a bench prototype for initial tests and to assist in the characterization of the mechanical structure, electronics and optics. Although we are designing a proof of concept instrument for laboratorial operation, we are defining the main requirements close to the requirements for space-based operation. The schematic drawing of the absolute radiometer is illustrated in Fig. 1. The precision aperture and the conical cavity are the key elements of the radiometer that determine the performance of the instrument. At this point, we have developed the process to build and characterize the sensor element, including the deposition of the thin film designed to absorb the solar radiation (see Fig. 2).

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