

5. Research and Supervision Results Obtained by Russian Scientists and Specialists during (in the course of) Implementation of Flight Scientific Programmes in cooperation and with assistance of Foreign Scientists and Specialists

In 2014-2015, the Laboratory of X-ray astronomy of the Sun (Lebedev Institute of RAS) obtained and published the following results obtained from the realization of flight research programs in space in collaboration with foreign researchers and scientists:

1. The **High-Resolution Coronal Imager (Hi-C)** was flown on a NASA sounding rocket on 11 July 2012. The goal of the Hi-C mission was to obtain high-resolution ($\approx 0.3 - 0.4''$), high-cadence (≈ 5 seconds) images of a solar active region to investigate the dynamics of solar coronal structures at small spatial scales.

The instrument consists of a normal-incidence telescope with the optics coated with multilayers to reflect a narrow wavelength range around 19.3 nm (including the Fe xii 19.5-nm spectral line) and a 4096×4096 camera with a plate scale of 0.1" pixel⁻¹. The target of the Hi-C rocket flight was Active Region 11520. Hi-C obtained 37 full-frame images and 86 partial-frame images during the rocket flight. Analysis of the Hi-C data indicates the corona is structured on scales smaller than currently resolved by existing satellite missions.

Reference: Kobayashi, Ken; Cirtain, Jonathan; Winebarger, Amy R. et al. "The High-Resolution Coronal Imager (Hi-C)", *Solar Physics*, Volume 289, Issue 11, pp.4393-4412 (2014)

2. Observing the Sun at high time and spatial scales is a step toward understanding the finest and fundamental scales of heating events in the solar corona. The high-resolution coronal (Hi-C) instrument has provided the highest spatial and temporal resolution images of the solar corona in the EUV wavelength range to date. Hi-C observed an active region on 2012 July 11 that exhibits several interesting features in the EUV line at 193 Å. One of them is the existence of short, small brightenings "sparkling" at the edge of the active region; we call these EUV bright dots (EBDs). Individual EBDs have a characteristic duration of 25 s with a characteristic length of 680 km.

These brightenings are not fully resolved by the SDO/AIA instrument at the same wavelength; however, they can be identified with respect to the Hi-C location of the EBDs. In addition, EBDs are seen in other chromospheric/coronal channels of SDO/AIA, which suggests a temperature between 0.5 and 1.5 MK. Based on their frequency in the Hi-C time series, we define four different categories of EBDs: single peak, double peak, long duration, and bursty. Based on a potential field extrapolation from an SDO/HMI magnetogram, the EBDs appear at the footpoints of large-scale, trans-equatorial coronal loops. The Hi-C observations provide the first evidence of small-scale EUV heating events at the base of these coronal loops, which have a free magnetic energy of the order of 10^{26} erg.

Reference: Régnier, S.; Alexander, C. E.; Walsh, R. W.; Winebarger, A. R. et al. "Sparkling Extreme-ultraviolet Bright Dots Observed with Hi-C", *The Astrophysical Journal*, Volume 784, Issue 2, 11 (2014).