Within the present project, we intend to analyze solar X-ray spectra from archival NASA database (https://umbra.nascom.nasa.gov/smm/). These Bent Crystal Spectrometer (BCS) spectra were observed from the Solar Maximum Mission (SMM), the NASA orbiting observatory. SMM observed the Sun in a wide energy interval from optical range through UV, EUV, X-rays to gamma range. Notwithstanding that BCS measurements were obtained ~30 years ago, they still represent the best ever spectra observed in the range between 1.7 and 3.3 Å (0.17-0.33 nm).

The database contains approximately 200000 spectra for hundreds of flares observed in eight partially overlapping spectral bands. These spectral bands were selected to allow making full plasma diagnostics for hot (5 – 30 MK) kernels present in flares and active regions. The kernels reach their high temperatures due to sudden release of magnetic energy stored in non-potential magnetic configurations of active regions related to sunspots on the visible disc of the Sun. During impulsive energy release, electrons and protons are being accelerated to high energies, plasma becomes strongly turbulent and part of the denser solar layers is evaporated filling magnetic loop structures of the corona.

Understanding the flare energy release processes is an important part of astrophysics and is comprehensively being investigated at present using space-borne instruments placed on SOHO, RHESSI, Hinode and SDO for instance. However, in the foreseen future no high resolution soft X-ray instruments are planned to be put in orbit to observe the Sun with spectral resolution comparable to that of the BCS on SMM. In the BCS spectra, strong emission lines are seen formed in the multi-million degree plasma kernels. Shape of the spectral lines and in particular, their intensities contain information on local plasma temperature, ion temperature, degree of turbulence, plasma density and bulk plasma motions. Line-to-continuum intensity ratios depend on plasma chemical composition and their interpretation allow for determinations of Ca and Fe abundances. So, the BCS spectra contain invaluable information on plasma conditions where the flare energy release takes place. The most of analyses of BCS observations have been performed many years ago when tens of research results were published. Nevertheless, at those times the numerical and atomic theory limited number of events that have been studied. At present these limitations are no longer present. Therefore within the scope of the present project we plan to reduce all available SMM BCS spectra (~200000) using modern algorithms and atomic databases (i.e. CHIANTI). We will use methods recently under development in our team. We plan to complement the atomic databases with calculations of hundreds of so called satellite lines using Cowan quantum atomic code (Los Alamos National Laboratory, August 1993, https://www.tcd.ie/Physics/people/Cormac.McGuinness/Cowan/). Only recently, a full description of the BCS instrument became available (Rapley, Sylwester & Phillips, 2017) that allows for the absolute calibration of spectra for the first time. Such calibrated spectra will contain nearly full information on the physical characteristics of hot flaring plasmas. The energy contained in flare has no equivalent in terrestrial laboratories as it may reach 10^{32} ergs. Rapid release of such large energy abruptly changes the state of the plasma in a way similar to thermonuclear explosion. Plasma of similar conditions to flares can be obtained in small amount for a short time in the laboratory Tokomak or EBIT devices. Investigations of flaring plasma will allow to study energy release processes in scales not accessible in the laboratory. During flare impulsive phase, the hard and soft X-ray emission is ubiquitous as a consequence of non-thermal and non-equilibrium processes. These processes strongly affect the observed line shapes and changes line intensities by orders of magnitude. The particle energy distribution functions differ from Maxwellian, and the ionization state may be far from equilibrium. Plasma moves with velocities reaching hundreds of km/s. These are just the quantities we will look into in detail based on the archive BCS spectra. In order to make a detailed analysis of spectral line profiles, we will clean the spectra from the instrumental broadening through deconvolution using a novel approach based on maximum likelihood Bayesian algorithm of Withbroe-Sylwester, (1980). The methodology of non-equilibrium and non-stationary plasma analysis is described in recent review by Dzifcakova et al. (2017) with the author of the present project as the co-author. We intend to analyze approximately 100 flares and perform the statistical study of the results obtained. The plan is to publish the results in ~10 papers to be submitted to leading astrophysical journals.