Early results for the STIX image reconstruction problem: imaging from visibility amplitudes

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The Spectrometer/Telescope for Imaging X-rays (STIX) is the instrument of the Solar Orbiter mission conceived for the observation of the hard X-ray flaring emission, with the objective of providing insights on the diagnosis of thermal and non-thermal accelerated electrons at the Sun. The STIX imaging system is composed of 30 pairs of tungsten grids, each one placed in front of a four-pixel detector, and produces as many Fourier components of the angular distribution of the flaring source, via Moiré pattern modulation. Therefore, the data recorded by STIX, named visibilities, can be interpreted as a sparse sampling of the Fourier transform of the X-ray signal and the corresponding image reconstruction problem requires the inversion of the Fourier transform from limited data, usually addressed with regularization techniques. Since the current calibration status of STIX measurements still prevents the use of visibility phases for imaging purposes, here we propose a parameter identification process based on forward fitting just the amplitude of the experimental visibilities. Specifically, we have parameterized the flaring source by means of pre-assigned source shapes (e.g., circular and elliptical bi-variate Gaussian functions), and we relied on several approaches to non-linear optimization in order to estimating the shape parameters. In particular, we have implemented a forward-fit method based on deterministic chi-squared minimization, a stochastic optimization algorithm and a deep neural approach based on ensemble learning, also equipping them with an ad hoc statistical technique for uncertainty quantification. The performances of the three approaches are compared in the case of both microflares and M class events recorded by STIX during its commissioning phase and the validation of results is realized also exploiting the EUV information provided by the Atmospheric Imaging Assembly within the Solar Dynamics Observatory.