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Microlocal analysis of Fourier Integral Operators in scattering tomography

We present a novel microlocal analysis of generalized Radon transforms (which are Fourier integral operators) that describe the integrals of L^2 functions of compact support over surfaces of revolution in $\mathbb{R}^n$ of C^∞ curves defined by a smooth function $q : [0, \infty) \to [0, \infty)$. We show that the Radon transforms are elliptic Fourier Integral Operators (FIO) and provide an analysis of the left projections Π_L. Our main theorem shows that Π_L satisfies the semi-global Bolker condition if and only if $g = q'/q$ is an immersion. An analysis of the visible singularities is presented, after which we derive Sobolev smoothness estimates for these generalized Radon FIO.

Our theory has specific applications in Emission Compton Scattering Tomography (ECST) and Bragg Scattering Tomography (BST). We show that the ECST and BST integration curves (or surfaces in $\mathbb{R}^3$) satisfy the semi-global Bolker Condition and provide simulated reconstructions from ECST and BST data. Additionally we give example "sinusoidal" integration curves which do not satisfy Bolker and provide simulations of the image artifacts. The observed artifacts in reconstruction are shown to align exactly with our predictions.

This is joint work with James Webber (Brigham and Women's Hospital, formerly Tufts University).