Microlocal analysis of seven-dimensional Radon transforms for Compton scattering tomography

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Abstract: We present a microlocal analysis of two novel Radon transforms of interest in Compton Scattering Tomography (CST), which map compactly supported square integrable functions in $\mathbb{R}^3$ to their integrals over seven-dimensional sets of apple and lemon surfaces. Specifically, we show that the apple and lemon transforms are elliptic Fourier Integral Operators (FIO), which satisfy the Bolker condition. After an analysis of the full seven-dimensional case, we focus our attention on lower dimensional subsets of apple and lemon surfaces. We consider apples and lemons with axes all in the vertical direction and with source on the plane $z = -1$ and detector on the plane $z = 1$. Such data have applications in airport baggage and security screening. In this case, the apple transform is shown to violate the Bolker condition, and some artifacts occur on apple-cylinder intersections. The lemon transform is shown to satisfy the Bolker condition, when the support of the function is restricted to the strip $\{(x, y, z) \,|\, z \in (0, 1)\}$.

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