Quadrature by Parity Asymptotic eXpansions (QPAX) for scattering by high aspect ratio particles

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The study of scattering by a high aspect ratio particle has important applications in nanophotonics problems, including sensing and plasmonic imaging. To illustrate the effect of parity and the need for adapted methods (in the context of boundary integral methods), we consider the scattering in two dimensions by a sound-hard, high aspect ratio ellipse. This fundamental problem highlights the main challenge and provides valuable insights to tackle plasmonic problems and general high aspect ratio particles. In this case we find that the boundary integral operator is nearly singular due to the collapsing geometry from an ellipse to a line segment. We show that this nearly singular behavior leads to qualitatively different asymptotic behaviors for solutions with different parities. Without explicitly taking this nearly singular behavior and this parity into account, computed solutions incur a large error. To address these challenges, we introduce a new method called Quadrature by Parity Asymptotic eXpansions (QPAX) that effectively and efficiently addresses these issues. We demonstrate the effectiveness of QPAX through several numerical examples, including the Dirichlet problem for Laplace's equation and scattering problems (sound-soft and sound-hard), and we discuss the application to plasmonic problems.

References

[1] C. Carvalho, A. D. Kim, L. Lewis, Z. Moitier, Quadrature by Parity Asymptotic eXpansions (QPAX) for Scattering by High Aspect Ratio Particles, *SIAM J. MMS* **19** (2021), pp. 1857–1884.

[2] Z. Moitier, C. Camille, Code Scattering_BIE_QPAX (2021), [DOI]