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A sparse spectral method on domains bounded by planar algebraic curves

We develop a sparse spectral method for solving partial differential equations on a class of two-dimensional geometries bounded by algebraic curves. The numerical method uses generalised bivariate Koornwinder polynomials, which form a basis that is orthogonal but not ordered by degree. The generalised Koornwinder polynomials are built from new families of univariate semiclassical orthogonal polynomials whose associated operator matrices are computed with linear complexity in the number of basis functions. The generalised Koornwinder basis allows for sparse matrix representations of conversion (change-of-basis), multiplication and differentiation operators, while also enabling fast transforms. The efficiency and accuracy of the spectral method are illustrated through a series of numerical experiments. (This is joint work with Jiajie Yao and Sheehan Olver.)