Abstract numbers and algebra in PETSc

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Scientific computing related to solving partial differential equations (PDEs) frequently employ both real and complex numbers, consequently computation libraries such as PETSc provide support for these number types and their associated algebra. Other “exotic” number types such dual numbers, hyper-dual numbers and intervals are also highly desirable in the context of solving PDEs, however these are seldom available within HPC linear algebra and or discretisation libraries.

In this presentation I will summarise several exotic number types and discuss some of their potential uses when solving: linear PDEs, non-linear PDEs, discrete adjoint problems and PDE constrained optimisation problems. Using these as motivation, I will also describe how these exotic numbers can be supported within PETSc. The approach adopted is general (extensible), non invasive and allows users to select the particular number type representation at run-time. Moreover the general design is well suited to the characteristics of modern computational hardware and thus can efficiently exploit different forms of parallelism. Through a series of toy problems, the cost and performance of the exotic number implementations will be assessed.