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High-order Lagrange elements in FreeFem++

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FreeFem Days
December 17, 2025

Finite element solution of time-harmonic wave propagation problems

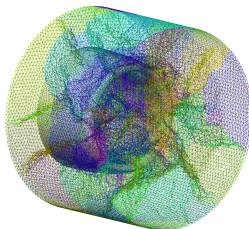
Helmholtz problem:

$$\begin{cases} -\Delta p - \kappa^2 p = s & \text{in } \Omega \\ \text{Boundary conditions} & \text{on } \partial\Omega \end{cases}$$

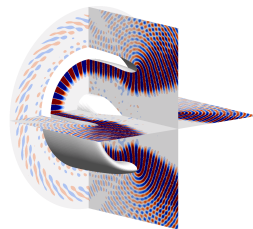
Finite element error:

$$\|p - p_h\|_{H^1} \leq C_1(\kappa h)^p + C_2\kappa^{(p+1)}h^p$$

Finite element mesh



Numerical field



High frequency (large κ)

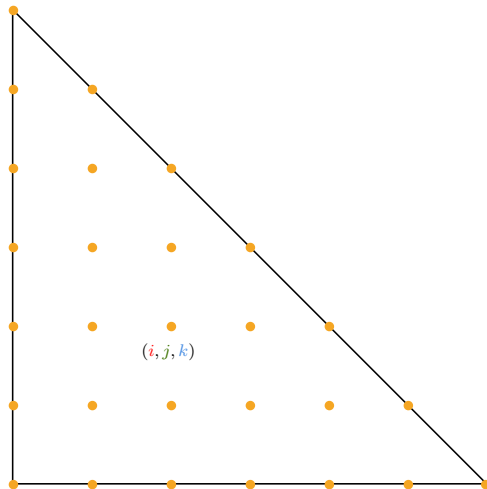
Phenomena close to resonance



Low approximation quality

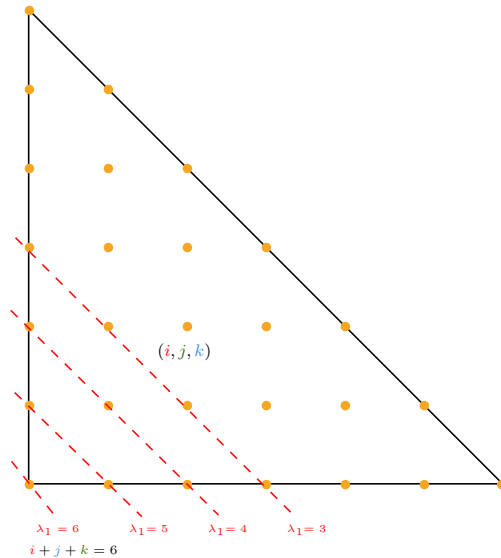


$\begin{cases} \text{Fine mesh (small } h) \\ \text{High-order basis functions (large } p) \end{cases}$

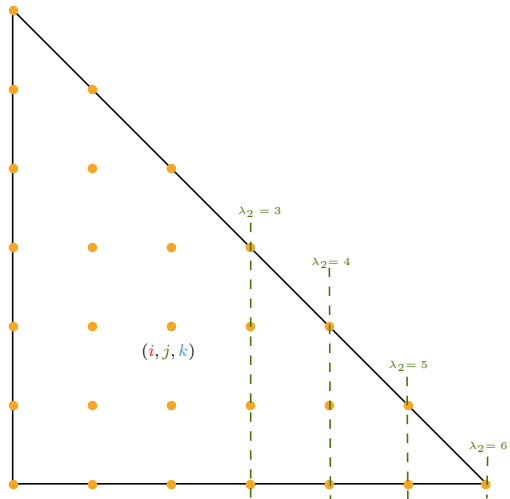


$$i + j + k = 6$$

Finite element P_6



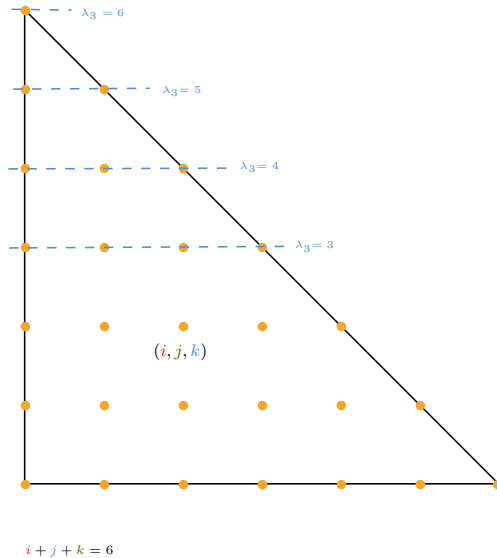
Finite element P_6



$$i + j + k = 6$$

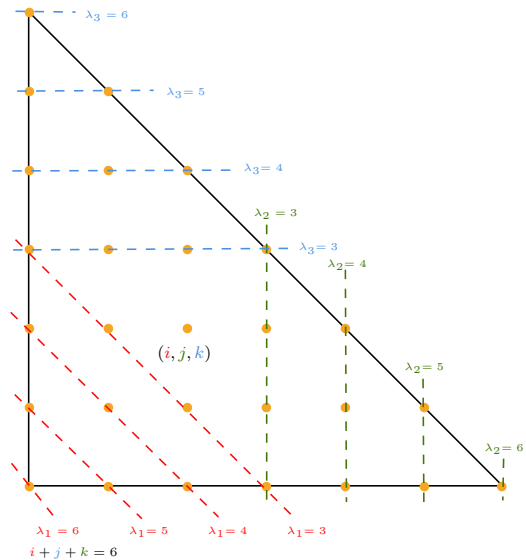
Finite element P_6

Polynomial basis



Finite element P_6

Polynomial basis



Finite element P_6

