

# Approximate Coupling Terms in Seismoelectric Theory: from Frequency Domain to Time Domain

Arjeta Heta, Hélène Barucq, Julien Diaz

December 2022

## Abstract

We consider Pride's equations [Pride, 1994], which model seismoelectric effects resulting from the coupling between seismic and electromagnetic waves in porous media. Pride's equations are thus equations of dynamic in porous media coupled with Maxwell's equations. The coupling is achieved in terms of a coefficient  $L$  which is easier to implement in the frequency domain as it is the inverse of a square root in frequency. Indeed, in the time domain, its full expression corresponds to an integral Fourier operator that is global in time and thus difficult to discretize accurately without extra computational costs. In practice,  $L$  is replaced in the time domain by a constant coefficient  $L_0$  which should reproduce the coupling accurately in the low frequency range. We are thus seeking for approximate expressions of the coupling term which can be derived in a frequency regime limited by the cut-off frequency. We propose to use Padé approximants which allows us to approximate the square root by rational functions of frequency. It is then possible to derive new coupling terms in the time domain by introducing auxiliary functions to handle the denominator of the rational functions. The new coupling terms are assessed by performing different types of numerical experiments: (a) in the frequency regime, we analyze the effect of the approximate coupling terms on the accuracy of the seismic and electric fields; (b) by applying Fourier transforms, we derive time domains seismograms that are compared with those obtained directly in time domain using the constant coefficient  $L_0$ ; (c) the approximate coupling terms are implemented in a time domain software to analyze their effect on the wavefields.

## References

[Pride, 1994] Pride, S. (1994). Governing equations for the coupled electromagnetics and acoustics of porous media. *Physical Review B*, 50(21):15678–15696.