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Energy barriers in three-dimensional micromagnetic models and the physics of thermoviscous magnetization

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Abstract

© The Author(s) 2018. A first-principle micromagnetic and statistical calculation of viscous remanent magnetization (VRM) in an ensemble of cubic magnetite pseudo-single domain (PSD) particles is presented. The theoretical methods developed apply to all magnetic particle sizes, from single domain to multidomain. The numerical implementation is based on a fast relaxation algorithm for finding optimal transition paths between micromagnetic local energy minima. The algorithm combines a nudged-elastic-band technique with action minimization. Initial paths are obtained by repetitive minimizations of modified energy functions. For a cubic PSD particle, 60 different local energy minima are identified, and all optimal energy barriers between them are numerically calculated for the case of zero external field. These results are used to estimate the energy barriers in weak external fields. Based on these, time-dependent transition matrices are constructed, which fully describe the continuous homogeneous Markov processes of VRM acquisition and decay. By spherical averaging, the acquisition of remanent magnetization in an isotropic PSD ensemble is calculated from laboratory to geological timescales. The modelled particle ensemble shows a physically meaningful overshooting of magnetization during VRM acquisition. The results also clarify why VRM acquisition in PSD particles can occur much faster than VRM decay, and therefore explain occurrence of extremely stable VRM as found in some palaeomagnetic studies.

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Keywords

Magnetic properties, Numerical modelling, Rock and mineral magnetism

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