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Gamma-magnetic normalization – new effect to reduce flux-gate magnetometer noise level

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It is the author's opinion confirmed by numerous experiments, that the FGM noise level (NL) is determined not by Barkhausen jumps during the core remagnetization from positive to negative state as the majority of designers believe, but by non-repeatability of the magnetic domains transition from negative to positive states and back. This shows the way how to reduce the magnetic noise: to manufacture the magnetic material with a structure which will create conditions for magnetic domain walls to glide easily and uniformly when changing their orientation leading to minimal efforts at cyclic remagnetization. Ideally, such a material may be represented as a solid "liquid" with freely floating uniform magnetic domains without walls friction. To reduce the specific NL of the materials, several post-melting processing technologies were developed. A set of experiments made by many investigators has shown that the best results gives the magnetic materials annealing in vacuum or in any inert gas applying by this during all annealing time the alternative magnetic field, imitating core excitation field during FGM operation. If to accept the "solid liquid" model, this mechanism of NL decreasing has clear physical explanation: permanent re-magnetization of domains leads to the structural improvements favorable namely for the homogenization of transitions, rise of temperature gives necessary energy for the impurities liquidation.

Probably, M. Acuna was the first who reported that during FGM operation in space its NL is decreasing with time and attributed this to the relaxation of mechanical stresses in the core material in weightlessness conditions [1]. We studied in details the conditions in which the core material is in space: weightlessness, vacuum and radiation. Mechanical stresses relaxation hypothesis was rejected because the internal forces in any solid body are much stronger as those to which a gravity force might have influence. Also the tests of FGM sensor in vacuum chamber both in operation and switched off conditions showed any influence of this parameter on NL. And radiation influence, the dose of which was selected approximately equal to yearly dose at near-Earth orbit ($\sim$10 krad), revealed interesting facts: the magnetic material itself and the FGM sensor in non-operation state showed any dependence on radiation, whereas this dose applied to the operating FGM sensor lead to the marked NL reducing. This new effect was named "gamma-magnetic normalization" and also can be explained by the accepted model: the mechanism is the same as above, but, because γ-quantum have much greater energy as thermal one, more "rigid" impurities are eliminated at γ-radiation action. The experimental results confirming this hypothesis are presented in the report.

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[1] Acuna M M, 2002. Space based magnetometers. Rev. Sci. Instr. 73(11) pp. 3717-36.