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# Comment on "Nature of the high-pressure tricritical point in MnSi"

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It is argued that Otero-Leal *et al.* [Phys. Rev. B **79**, 060401 (2009)] wrongly identified the coefficient at the second-order term of the Arrott equation with the coefficient at the quartic term of the Landau expansion, therefore deriving unsupported conclusions on the phase diagram of MnSi.

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Despite a long history of extensive study of the magnetic phase transition in the helimagnet MnSi, the phase diagram of the material is not completely understood. Most important but still controversial are the existence, location, and nature of a tricritical point on the transition line in MnSi, first suggested in Ref. 1. Until recently the existence of the tricritical point has not been in doubt though its location was disputed in Ref. 2. Meanwhile careful study of the magnetic phase transition in MnSi confirmed the first-order nature of the transition at least at ambient pressure,[3–6] as proposed long ago.[7] Furthermore, experiments at high pressure using helium as a pressure medium showed that the early claims on the existence of a tricritical point at the phase-transition line, based on an analysis of behavior of magnetic susceptibility, are possibly a result of misinterpretation of the experimental data.[8] So the general conclusion was that the magnetic phase transition in MnSi probably continued to be first order in the entire pressure range studied.[8] An attempt was made in Ref. 9 to resolve above issues based on "a direct analysis of the magnetic phase transition under pressure." Under "direct analysis" authors implied applications of the equation

$$H/M = a + bM^2 + cM^4 + \cdots , \tag{1}$$

where $H$ is the magnetic field and $M$ the magnetization. Equation (1), as suggested by Arrott,[10] is a typical mean-field relation and can be readily derived from the Landau expansion.[11] Normally Eq. (1) is used to plot $H/M$ vs $M^2$ (Arrott plot), which would yield a straight line at the temperature of second-order ferromagnetic phase transition when critical fluctuations can be neglected. Equation (1) needs to be modified to account for the contributions of critical fluctuation (see Ref. 12). It has to be emphasized that Eq. (1) is strictly applicable to ferromagnetic materials because only in this case magnetization can serve as an order parameter with magnetic field as a conjugate variable. Neglecting this important circumstance Eq. (1) was applied in Ref. 9 to the helical magnet MnSi, though it has been known for years that the Arrott approach does not work in case of MnSi (Ref. 13) for the following understandable reason. An order parameter for a helical magnet is a slow-varying spin density, which is not conjugate to the magnetic field (indeed magnetic field cannot create a helical order). Details of the Landau approach to the phase transition in MnSi see, for instance, in Refs. 7 and 14. Nevertheless, the authors of Ref. 9 analyzed the behavior of the coefficient $b$ in Eq. (1) as functions of magnetic field and pressure at temperatures slightly above the phase-transition points. They found again as in Ref. 13 a strongly nonlinear relationship between $H/M$ and $M^2$ but ignoring that they concentrated on variations in the coefficient $b$ in Eq. (1), which became negative at low magnetic fields at pressure above 3.5 kbar. Note that this fact would be relevant only in the ferromagnetic case. They then wrongly identified the coefficient $b$ with the coefficient at the quartic term of the Landau expansion and derived the unsupported conclusions about the phase diagram of MnSi. Finally, the statement that they have "put an end to the controversy about the nature of the magnetic phase transition and its evolution with pressure in MnSi" is thus ill founded.

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