**Serbyn *et al.* Reply:** Sergeev, Reizer, and Mitin (SRM) [1] dispute the conclusion of recent theories, particularly our Letter [2], which predict a giant fluctuation Nernst effect (NE) in superconductors. SRM claim that the NE on the contrary should be minuscule. We show that their underlying work [3] is erroneous and therefore there is no need to revise the existing theories. We also refute all other criticisms of SRM and demonstrate that our interpretation of the physics of the phenomenon is correct.

First, we briefly discuss relevant researches: In the last decade, an anomalously large NE was reported in the cuprates and in conventional superconducting films. On the theory side, it was demonstrated within the Ginzburg-Landau approach [4,5] that the fluctuation NE is enhanced by the parameter $E_F/T$ compared to a normal metal. This result was confirmed using Matsubara diagrammatic techniques in Ref. [6] (close to $T_c$, weak magnetic fields) and in [2], where we extended the theory to arbitrary magnetic fields and temperatures. Later, the same order of magnitude of the fluctuation NE was found using the Keldysh method [7].

Despite these convincing theoretical results and experimental facts, SRM have been insisting on the opposite point of view that the fluctuation NE is even smaller than in a metal, suppressed by an additional factor, $T/E_F$. SRM claims are based on their Ref. [3]. Having analyzed it, we found multiple errors and this detailed analysis is reported in Ref. [8]. In their recent Reply [9] on our criticism, SRM have finally specified the gauge used in Ref. [3]. Unfortunately, they still fail to correctly take the limit **k**, **Q** → 0 in the Kubo correlation function $\langle j_\alpha^Q(\mathbf{k} + \mathbf{Q})j_\beta^e(-\mathbf{k})\rangle$, again obtaining the same wrong answer. Since SRM fail to satisfy gauge-invariance, their Refs. [3,9] are simply wrong and do not provide a basis for revising the existing theories.

Now, we respond to specific criticisms: (i) SRM state that the thermoelectric tensor includes only the kinetic (Kubo-like), $\tilde{\beta}_{xy}$, contribution, but not the thermodynamic (magnetization), $cM_z/T$, term. First, this statement is in contradiction to all known theories of the NE, which have shown that both terms contribute to the signal, $\beta_{xy} = \tilde{\beta}_{xy} + cM_z/T$. Second, we note that even if the magnetization contribution were omitted, the NE in fluctuating superconductors would still be giant, provided that the error in calculating $\tilde{\beta}_{xy}$ made in Ref. [3] be corrected. Note that the magnetization term becomes crucial at low temperatures above $H_{c2}$ [2,7], where it cancels the otherwise divergent $\tilde{\beta}_{xy}$, thus being eventually responsible for the implementation of the third law of thermodynamics. Finally, we mention that decomposition of the Nernst coefficient into kinetic and thermodynamic parts is fully analogous to that of the Hall conductivity [10]. (ii) SRM claim that the giant Nerst signal "contradicts to experimental data." We disagree and reiterate that our theory does explain the NE in NbSi films, correctly predicting not only the magnitude of the signal, but also its temperature dependence [2]. Our theory should also work for other superconducting films, and a detailed comparison with experiment is required to judge its applicability for a particular material. The Cooper-channel contribution to the NE should also exist in metals with repulsive interaction, similar to fluctuation diamagnetism and conductivity [11]. (iii) Finally, SRM dispute our phenomenological formula for the Nernst coefficient, $\nu_N = (\sigma/ne^2c)(d\mu_{c.p.}/dT)$, and erroneously argue that the NE is negligible because the chemical potential of fluctuating Cooper pairs, $\mu_{c.p.}$, is zero. The key point overlooked in [1] is that the fluctuating Cooper pairs do not form an isolated system, but coexist with the subsystem of quasiparticle excitations. Hence $\mu_{c.p.}(T > T_c) \neq 0$. We stress that while our microscopic calculations do not rely on this phenomenology, they strongly support it.

Leaving aside the Comment of SRM, we note that the remaining problem in the field is to reconcile the Matsubara [2] and kinetic [7] approaches, which differ in numerical factors of order one in some asymptotes (this discrepancy is likely related to the definition of a heat vertex). However, all theories agree on the main issues and therefore the fact that superconducting fluctuations yield a giant NE in two dimensions is now firmly established.

M. N. Serbyn,[1] M. A. Skvortsov,[2] A. A. Varlamov,[3] and V. Galitski[4]
[1]Department of Physics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, USA
[2]Landau Institute for Theoretical Physics Chernogolovka, Moscow Region, 142432, Russia
[3]SPIN-CNR, Viale del Politecnico 1, I-00133 Rome, Italy
[4]Joint Quantum Institute, Department of Physics University of Maryland College Park, Maryland 20742-4111, USA

[1] A. Sergeev, M. Reizer, and V. Mitin, preceding Comment, Phys. Rev. Lett. **106**, 139701 (2011).
[2] M. N. Serbyn et al., Phys. Rev. Lett. **102**, 067001 (2009).
[3] A. Sergeev, M. Y. Reizer, and V. Mitin, Phys. Rev. B **77**, 064501 (2008).
[4] S. Ullah and A. T. Dorsey, Phys. Rev. Lett. **65**, 2066 (1990).
[5] I. Ussishkin, S. L. Sondhi, and D. A. Huse, Phys. Rev. Lett. **89**, 287001 (2002).
[6] I. Ussishkin, Phys. Rev. B **68**, 024517 (2003).
[7] K. Michaeli and A. Finkel'stein, Europhys. Lett. **86**, 27007 (2009).
[8] M. N. Serbyn et al., arXiv:1012.4316.
[9] A. Sergeev et al., arXiv:1101.4168.
[10] L. Smrcka and P. Streda, J. Phys. C **10**, 2153 (1977).
[11] L. G. Aslamazov and A. I. Larkin, Sov. Phys. JETP **40**, 321 (1975); B. L. Altshuler, A. A. Varlamov, and M. Yu. Reizer, Sov. Phys. JETP **57**, 1329 (1983).