Reply to "Comment on 'Heat fluctuations in Brownian transducers'"

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In this Reply we show that to characterize our paper as "mathematically incomplete and physically faulty" is incorrect. Moreover, we never claimed that there is not a fluctuation theorem for the heat probability distribution in Brownian transducers operating between two heat reservoirs. We studied the conditions of observability of the Jarzynski-Wojcik fluctuation theorem [C. Jarzynski and D. K. Wojcik, Phys. Rev. Lett. **92**, 230602 (2004)] in a model system in which the coupling term is relevant and the observation time is necessarily finite.

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It is incorrect to state that our paper [1] is mathematically incomplete because we did not evaluate all the cumulants of the probability distribution for the heat exchange in the steady-state regime. It is indeed worthy to note that an exact solution of the cumulant generating function is possible for our simple model. However, this does not justify the claim that our calculation is incomplete. In addition, the author of the Comment says that our paper is physically faulty, but does not clearly specify which part. We assume that the author is referring to the Gaussian approximation for the probability distribution $p(Q)$. This is an exaggerated interpretation. As any reader can check, we explicitly stated on page 4 that $p(Q)$ is not rigorously Gaussian because $Q(t)$ is a nonlinear functional of a Gaussian Orstein-Ulhenbeck process. Nevertheless, at the same time we empirically found and showed by analyzing numerical data of $p(Q)$ that, for large values of kt_0 (not smaller that 100) without high temperature gradients, it could be fitted by a Gaussian distribution with the first and second cumulants already obtained analytically in our paper.

Beyond these considerations, we must address the crucial issue of whether there is a fluctuation theorem or not, since it is the main criticism of our work. We never said in our paper that there is no fluctuation theorem. As we made clear in the abstract, we were concerned about the applicability of the Jarzynski-Wojcik (JW) fluctuation theorem for heat exchange [2] to Brownian devices in which the coupling mechanism is a relevant part. In the case in which the tails of the distributions can be measured, we presented numerical evidence that the system considered does not verify the JW relation. Obviously, this is not due to the theorem being wrong but to the different conditions of our model and preparation which may not correspond to those of the theorem.

A different fluctuation relation, which was not within the scope of our work, is the one to which the author of the Comment refers, namely, the Gallavotti-Cohen (GC) theorem [3]. This relation is a remarkable result, but it is derived in the limit of time going to infinity. We specifically considered the JW theorem because it is derived for any finite time t_0. The author does not note this in the Comment. Both expressions (the JW and GC theories) coincide, but the conditions of their derivation and their domain of applicability are very different. In the Comment, its is proved, by means of the large deviation function formalism (which requires the $t \to \infty$ limit), that the cumulant generating function of our model has a particular symmetry. It is very important to note that such a symmetry by itself does not lead to the fluctuation relation, since the role of initial conditions together with the existence of a boundary term can be very relevant [4,5].

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