Pagnani, Parisi, and Ricci-Tersenghi Reply: In the preceding Comment [1] to our paper [2] Hartmann presents a powerful algorithm to find the ground states of the random RNA model we have studied in [2]. He also shows some interesting results on the overlap distribution $P(q)$ at zero temperature. His conclusion is that at $T = 0$ and in the thermodynamical limit the $P(q)$ is a delta function. We would like to point out that his result is not in contradiction with ours and that none of the conclusions we reached in [2] are to be modified.

In our paper we already commented about the shrinking of the $P(q)$ at $T = 0$, finding that the variance decreases like $\sigma^2 \propto L^{-0.4}$. However, because of the small exponent, we were not able to determine the asymptotic value of the variance from our data ($L \leq 1024$) and we believe that even with Hartmann's data ($L \leq 2000$) this extrapolation is still a hard task. Note that the relevant observable is the width σ which scales with an exponent of order 0.2–0.25, according to ours or Hartmann's results. We also measured [2] the width in the high temperature phase and we obtained $\sigma \propto L^{-0.5}$ as it should be according to the central limit theorem.

Nevertheless, assuming that according to [1] the model studied in [2] at $T = 0$ has a delta-shaped $P(q)$, our conclusions regarding the replica symmetry breaking (RSB) transition will remain unaltered. Indeed there are disordered models which have an RSB phase together with a trivial $P(q)$ at $T = 0$, showing that the two properties are completely unrelated. The most famous among these is the Sherrington-Kirkpatrick (SK) one [3], which is widely considered the prototype of disordered models. Below the critical temperature the SK model has an RSB phase [4]; however, at $T = 0$ the $P(q)$ is a delta function centered in $q = 1$.

An expert reader may object that, differently from the SK model, the random RNA model we have studied in [2] has a finite entropy at $T = 0$ and then the above argument may no longer hold. However, we do not expect any significant difference and we corroborate our belief with the most recent results on the Edwards-Anderson (EA) model with discrete couplings ($\pm J$) in dimensions $d = 3, 4$. In this model at $T = 0$ there is a finite entropy and a trivial delta-shaped $P(q)$ [5]; however, as soon as the temperature is different from zero the $P(q)$ becomes broad [6]. Moreover, in the $\pm J$ EA model, independently from the existence of a finite temperature phase transition (which is present in $d = 3, 4$ and absent in $d = 2$), the $P(q)$ at $T = 0$ is always a delta function [5]. If one is interested in understanding the presence of a finite temperature phase transition through the ground states calculation, methods more sophisticated than the simple $P(q)$ estimation should be used [6]. Their application to the random RNA models studied in [2,7] would be very welcome.

The above observations should clarify the importance of studying the model at finite temperatures, where a broad $P(q)$ indeed signals the presence of an RSB phase. We presented the key results obtained at $T \neq 0$ in the third figure of [2]. They show the existence of a phase transition to a phase where the replica symmetry seems to be broken. Moreover, in the discussion following Fig. 3 in [2] we also took into account the possibility that the RSB would be simply given by finite size effects and that it would disappear in the thermodynamical limit. Even in this case the zero-energy excitations between different "valleys," which mimic the presence of RSB, would play a fundamental role in the understanding of the model.

Finally, in order to confirm the glassy nature of the transition at finite temperature, we are currently implementing a Monte Carlo study of the model dynamics. Preliminary results clearly display typical glassy features, such as aging. We hope that these results will eventually render a coherent scenario of RSB both from dynamical and thermodynamical points of view.

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