Cilibrizzi *et al.* Reply: The authors of the preceding Comment (AC) [1] critique a conclusion of our recent work [2] that their reports of dark solitons (DS) and half-dark solitons (HDS) [3–7] should be reconsidered.

We emphasize that our work does not question the theoretical framework of the Gross-Pitaevskii equation, which admits soliton solutions. However, it suggests that the experimental evidence provided in Refs. [3–7] is insufficient.

The AC state that the claims of DS "are not based on the density and phase patterns only, but are further supported by a complete study of the physics as a function of the fluid density" and cite works using different microcavities, defects, and excitation conditions. However, combining evidence of different studies is only valid if the investigated object is comparable, which is not the case in Refs. [3–7]. It remains therefore essential that sufficient evidence is presented for each claim of DS. Furthermore, we emphasize that to perform a study as a function of the fluid density, it is a prerequisite to determine the density and its variation. This, however, has in general not been done in the above cited works.

Let us consider in more detail Ref. [3], containing in Fig. 1(a) the candidate for an oblique DS which was selected by the AC for further analysis. In Ref. [3] it is stated that "An unambiguous characteristic of solitons in BECs is the phase jump across the soliton," suggesting that other features are not necessary to support the claim, in line with the missing determination of the fluid density for all data shown in that work. The excitation power dependence shown in Figs. 3(a)–3(c) taken on a different defect is then claimed to display a transition from a subsonic regime to DS. However, the turbulent regime claimed in Fig. 3(b) is at a lower power than Fig. 1(a), and the DS candidate in Fig. 3(c) resembles Fig. S3C in the linear regime, with the phase jump absent already at $\sim 15\ \mu\mathrm{m}$ from the defect [Fig. 3(f)]. Two further defects are shown in this work without power dependence and observation of soliton doublets and quadruplets is claimed.

Moreover, DS in polariton microcavities are claimed at subsonic velocities ($M < 1$), i.e., for a Mach number $M = 0.49$ in Fig. 1(a) (already at $14\ \mu\mathrm{m}$ from the defect) and $M = 0.6$ in Fig. 3(c) where oblique DS are "absolutely unstable" [8] and AC have previously predicted vortex nucleation in both atomic [8] and polariton [9] condensates.

In Ref. [7], claiming HDS, no excitation power dependence is provided, neither a measurement of the excitation power nor of the fluid density. There are similar issues to different extents with the above cited publications.

The AC then argue that the "fanlike shape" can be attributed to the linear regime. We note that the dark-soliton candidates in the literature [3–7] are all qualitatively different, such that a specific shape is not a suited criterion. It has actually been shown that the angle between the dark notches depends on the parameters of the obstacle and the excitation [10].

In Ref. [2], we proposed the healing length condition to discriminate DS from diffractive patterns. We welcome the new analysis reported in Fig. 1(d) of Ref. [1]. Unfortunately, an arbitrary scaling was used since the absolute density is unknown. We emphasize that in a polariton quantum fluid, the healing length is quantitatively determined by the same variables used to calculate the speed of sound in Ref. [3]. Nevertheless, the AC do not report this healing length either in Ref. [3] or in their Comment [1]. Furthermore, the measured width in Fig. 1(d) shows fluctuations by a factor of 2 along the propagation, inconsistent with the evolution of the healing length expected from the density, and thus with the soliton interpretation. Furthermore, the observed change of the expected healing length is of the same magnitude as the fluctuations, such that no significant conclusions can be drawn from the overlap. Therefore, our proposition "to use the healing length condition to verify DS formation, which should be fulfilled over a range of polariton excitation densities" [2] is not satisfied.

In conclusion, we emphasize that when demonstrating nonlinear behavior one first has to establish the linear behavior at low densities, and then show deviations from it at higher densities, while providing sufficient information to quantify the density so that a reliable comparison can be made with theoretical predictions. Polariton dynamics depend strongly on the depth and size of the scattering defects and the excitation conditions used. It is therefore required to perform a suited study for each investigated defect to provide necessary and sufficient evidence of DS formation.

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