Spontaneous and Superfluid Chiral Edge States in Exciton-Polariton Condensates: Supplementary Information

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Topological dispersion in an unpatterned microcavity ($V = 0$) under resonant pumping.— We consider a patterned optical pump $F_x(\mathbf{x})$ taking the form of a kagome lattice, represented as a superposition of six plane waves:

$$F_x(\mathbf{x}) = F_0 \sum_{n=1}^{6} e^{i(\mathbf{k}_n.\mathbf{x}+\phi_n)} \tag{S1}$$

where F_0 defines the amplitude; the wavevectors are $\mathbf{k}_{1,2} = k_0(\pm\sqrt{3}/2, 1/2)$, $\mathbf{k}_2 = k_0(\sqrt{3}/2, 1/2)$, $\mathbf{k}_{3,4} = k_0(0, \pm 1)$, and $\mathbf{k}_{5,6} = k_0(\pm\sqrt{3}/2, -1/2)$, where $k_0 = 4\pi/(\sqrt{3}a)$; and the phase factors are $\phi_{1,2,3,4} = 0$ and $\phi_{5,6} = \pm 2\pi/3$. Under resonant pumping, the terms $P(\mathbf{x})$ and Γ_{NL} are typically neglected in the modelling of exciton-polariton systems. Under such conditions, it is straightforward to show (for example by writing Eq. 3 in reciprocal space) that the polariton field $\psi_x(\mathbf{x})$ will adopt the intensity and phase structure of $F_x(\mathbf{x})$ in the stationary regime. The dispersion of the y-component is then obtained from application of the Bloch theory, giving the result shown in Fig. S1. One sees a clear gap in the dispersion, where bulk states do not appear. The gap is topological, being bridged by a pair of chiral edge states that are localized on opposite edges of the strip.

This scheme may appear similar to that considered in Ref. [1], which was based on a similar equation to Eq. 5, but the context and interpretation is very different. Here, by exciting a field with one linear polarization (x), we find that topological behaviour appears in the opposite linear polarization (y). It should be noted that the dispersion of y-polarized polaritons can be distinguished from the more highly populated x-polarization using polarization filtering. In addition, since the problem has been effectively divided into two parts, that is, solution of the x-polarized field from Eq. 3, and the dispersion of the y-polarized field from Eq. 5, it becomes easier to find parameters that give a topological bandgap. In particular the dispersion shown in Fig. S1 depends on the scaled parameter $\alpha'|\psi'_x|^2 = 160$ and shows a topological gap of typical size $\sim 5\epsilon$.

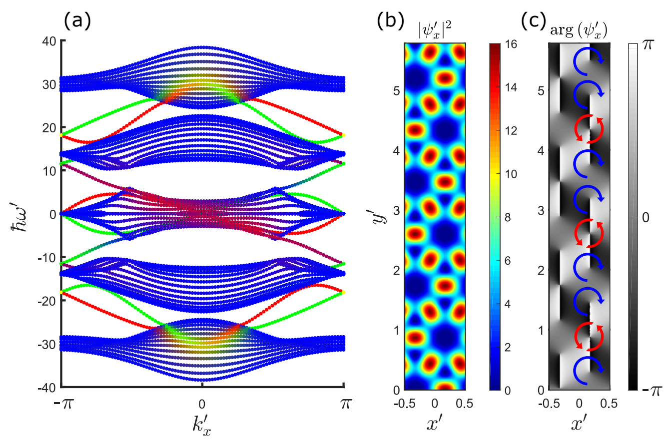

Figure **S1**. (a) Optically-induced topological dispersion under resonant coherent pumping. (b) Density of the condensate vortex lattice in the upper half the of strip. (c) Phase of the condensate. Red double arrows indicate charge 2 vortices whereas blue single arrows charge -1 vortices. Parameters: $\Gamma' = 0.5$, $\alpha'|\psi'_x|^2 = 160$, $E'_p = 41$, $V' = 0$, $P(\mathbf{x}) = 0$, $\Gamma_{\mathrm{NL}} = 0$.

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