a tight-binding model of Eq.(1) and in the averaging limit, which neglects weak light transfer among waveguides due to non-resonant coupling terms. We checked the possibility of observing rectification of light refraction beyond such approximations by a beam propagation analysis of Eq.(1). In the simulations, circular channel waveguides with a super-Gaussian index profile $\Delta n(x,y) = \Delta n_{A,B} \exp\{-[(x^2+y^2)/w^2]^3\}$, with radius w and index changes Δn_A and Δn_B in the primary and auxiliary arrays, are assumed. The vertical distance d_v between the two arrays is chosen to be $d_v = \sqrt{3}d/2$, i.e. the zigzag is defined by an equilateral triangle. As an input beam, we typically assumed an elliptical Gaussian beam, with a tilting angle θ (in the x direction) smaller than the Bragg angle θ_B to excite the lowest band of the array. The vertical beam position and size are adjusted to couple a few waveguides of the primary array. Examples of rectified light refraction, observed in the curved arrays for a few values of beam incidence angle θ, are shown in Fig.2. In the figure, the integrated beam intensity distribution $\int |\psi(x,y)|^2 dy$ versus propagation distance z is shown and compared to the behavior that one would observe if the arrays were straight, i.e. with usual discrete light refraction patterns. For the chosen array parameters and wavelength, the coupling rates and propagation mismatch are estimated to be $\kappa_{aa} = \kappa_{bb} \simeq \kappa_{ab} \simeq 1.939$ cm^{-1} and $\sigma \simeq 16.19$ cm^{-1}, corresponding to a radius of curvature $R = 4$ cm and a semi-cycle period $z_0 = 8.1$ mm according to Eq.(4). The numerical results clearly show that, for curved arrays, light refraction always occurs at the angle $\theta_r = d/(2z_0)$, regardless of the beam incidence angle θ, and discrete diffraction is well suppressed as a result of the controlled transport mechanism. Of course beam refraction is reversed when the position of the elliptical input beam is shifted to excite waveguides of the auxiliary array. As an example, Fig.3 shows rectification of light refraction when the array B_n is excited at the input by an elliptical Gaussian beam at normal incidence. Note that, as compared to Fig.2(a), the refraction angle of discretized light is now reversed.

In conclusion, rectification of light refraction in a periodic photonic structure, which provides an example of an Hamiltonian ratchet system, has been proposed, together with a possible experimental implementation based on periodically-curved zigzag waveguide arrays.

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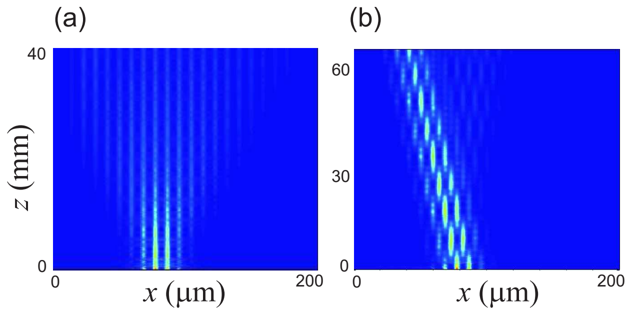

Fig. 3. (Color online) Same as Fig.2(a), but for an elliptical Guassian input beam vertically displaced to excite waveguides of the auxiliary array. In (a) the arrays are straight, whereas in (b) they are periodically-curved.

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