



















interferometer can be used to control the phase difference between light incident in the two waveguides [10,14].

Note that the optical frequency is many orders of magnitude larger than the mechanical resonance frequency, which is in the MHz range. Because the instantaneous optical force oscillates much faster than the mechanical motion, we consider the effect of the time-averaged, or “smoothed,” optical force on the waveguides, where the average is taken over the optical cycle. Assume the incident power is switched on and remains fixed. Driven by the optical force, the waveguides will start to deform. A steady-state displacement will be reached after a period of time proportional to the mechanical quality factor divided by the mechanical resonance frequency. In this paper, we focus on the static mechanical Kerr coefficient  $n_2^m$  caused by the steady-state displacement. However, for fixed power, larger displacements can be obtained by modulating the incident optical power at the mechanical resonance frequency [20]. The displacement will vary as a function of time throughout the period of mechanical vibration. At the peak displacement value, the instantaneous  $n_2^m$  reaches its maximum.  $n_2^m$  will be increased by a factor of  $Q_{\text{mech}}$  with respect to the case of static displacement, where  $Q_{\text{mech}}$  is the mechanical quality factor. However, if the average mechanical displacement is zero, the average value of  $n_2^m$  will also be zero.

## 5. Conclusion

We have investigated mechanical Kerr effects in a coupled-waveguide system exhibiting both attractive and repulsive forces. The optical force can be related to the change in effective index with separation at frequency. This formulation makes it clear that either an attractive or repulsive force gives rise to a positive mechanical Kerr coefficient. Values several orders of magnitude larger than the intrinsic Kerr coefficient are obtained for waveguides in which the optical mode approaches the air light line.

Since the mechanical Kerr effect results from physical motion, the time scale for response will be slower than for the intrinsic Kerr nonlinearity. At the same time, however, the magnitude is orders of magnitude larger. This suggests the potential for the design of ultra-low threshold, integrated optical devices such as all-optical transistors and isolators [25] that use the mechanical Kerr effect. Such devices might respond to the *average* power in an optical data stream, where the time-average is related to the time scale for mechanical response, and ultimately find use in the regulation of on-chip optical networks.

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