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# Optimal design of two-dimensional external cavities for delayed optical feedback

Shinji Orihara[1,*], Koei Koyama[1,#], Susumu Shinohara[2], Satoshi Sunada[3], Takehiro Fukushima[4], and Takahisa Harayama[1]

[1]Department of Applied Physics, School of Advanced Science and Engineering, Waseda University, 3-4-1 Okubo, Shinjuku-ku, Tokyo 169-8555, Japan

[2]NTT Communication Science Laboratories, NTT Corporation, 2-4 Hikaridai, Seika-cho, Soraku-gun, Kyoto 619-0237, Japan

[3]Faculty of Mechanical Engineering, Institute of Science and Engineering, Kanazawa University, Kakuma-machi, Kanazawa, Ishikawa 920-1192, Japan

[4]Department of Information and Communication Engineering, Okayama Prefectural University, 111 Kuboki ,Soja, Okayama 719-1197, Japan

Email: *kh5462@asagi.waseda.jp, #poohtaro-koei@toki.waseda.jp

Recently, chaotic semiconductor lasers with delayed optical feedback have attracted renewed interest, because of their usefulness as an entropy source for physical random number generation [1]. It has been reported that, for obtaining strongly chaotic outputs suitable for random number generation, a sufficiently long external cavity (e.g. 2 mm) for delayed optical feedback is necessary. This requirement is an obstacle to the miniaturization of the device. As an idea to resolve this problem, folding an optical path in a two-dimensional (2D) external cavity has been proposed [2], where the cavity consists of a deformed microdisk and two linear waveguides. This cavity makes it possible to form a path much longer than the cavity diameter [see Fig.1 for the cavity shape]. For example, a 2.8-mm path was formed for a device with the diameter of 0.3 mm [2].

In this approach, the cavity shape needs to be carefully designed to suppress light diffusion due to the multiple reflections. In this work, we are interested in an optimal cavity shape that maximizes the feedback strength. We simulated the light propagation in the 2D external cavity by the flux of rays, and determined an optimal cavity shape where the maximal feedback strength is expected. By performing wave simulations based on the FDTD method, we confirmed the improvement of the feedback strength up to 8.9% as compared to the previously reported cavity shape.

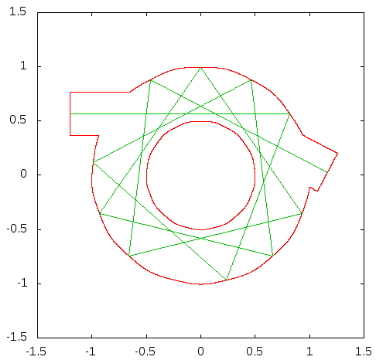


Fig.1: 2D external cavity with a folded long path.

[1] A. Uchida, "Optical Communication with Chaotic Laser" (Wiley-VCH, Weinheim, 2012).

[2] S. Shinohara, S. Sunada, T. Fukushima, T. Harayama, K. Arai, and K. Yoshimura, Appl. Phys. Lett. **105**, 151111 (2014).