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Spotlight on "Effect of Injection Current and Temperature on Signal Strength in a Laser Diode Optical Feedback Interferometer"

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Spotlight summary:

Backreflections from the external world are among the worst enemies of lasers. Most people with some knowledge in optics are well aware of that. Optical feedback can induce fluctuations in the output power, lasing frequency drifts, bifurcation phenomena, mode hopping and ultimately chaos. In other words, under strong feedback conditions a laser can behave very differently from what a laser is expected to do. Yet, in some circumstances, your worst enemy can even become your best friend...

Each time a system suffers from strong sensitivity to some external agents, we can think of exploiting this vulnerability for sensing. Backreflections from objects to be monitored are indeed at the basis of what is commonly known as optical feedback interferometry (OFI), which is one of the most widely employed techniques in sensing applications, for instance in measurements of displacement, velocity, and vibration.

In OFI, two possible approaches can be used to access information on the target. We can do it optically, by measuring the variations induced by the optical feedback on the intensity of the light emitted by the rear facet of the laser diode; or electrically, by measuring the voltage variations induced across the laser terminals. In both cases, to achieve high sensitivity, it is fundamental to

work with the maximum signal-to-noise ratio. It is not surprising that both optical and electrical OFI signals depend on the laser structure and on the operation parameters, such as the laser bias current. What is far less obvious is that the dependence of the OFI signal strength versus injection current can be dramatically different for the optical and electrical signals. Some observations of this tricky behaviour were reported in the literature, but a clear understanding of this phenomenon was still missing... until the work by Al Roumy and co-workers.

These researchers have succeeded at developing a simple model that provides a clear explanation of the dependence of the OFI signal on laser diode injection current and temperature. Compared to previous studies, the key used in their model is to include a realistic dependence of the laser slope efficiency on the injection current and temperature. Nothing more than that, yet extraordinarily effective. In fact, their model nicely shows why the optical signal strength increases with injection current, while the electrical signal is at a maximum just above the laser threshold, and subsequently decreases at higher injection current. Moreover, the same model provides also a clear explanation of the more pronounced decrease in the optical signal with temperature, compared to the electrical signal.

As a main result, golden rules to select the optimum injection current to maximise OFI sensitivity are provided for both optical and electrical read-out configurations. The biasing strategy is indeed radically different for the two schemes, the first exhibiting better sensitivity at higher bias current, the second having the optimal injection current close to threshold. This study was limited to single-mode laser structures, but the authors are confident on its extension to multiple transverse or longitudinal mode operation.

Finally, note that there is also lesson to be learned from the approach itself followed in this work. The model was derived from the Lang and Kobayashi equations, which were proposed more than

thirty years ago to study the effects of weak optical feedback on semiconductor laser properties. The results achieved by Al Roumy and coworkers were somewhat hidden inside these equations, but nobody had been able to unveil them before. This demonstrates that new stories may come from well-known models, so we must never believe that old models have already told us everything they can.

Yet, it's up to us to make them tell more.

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