Supplementary Material for

Accelerating speckle suppression by a degenerate cavity laser with an intracavity phase diffuser

Simon Mahler,[1,‡] Yaniv Eliezer,[2,‡] Hasan Yılmaz,[2] Asher A. Friesem,[1] Nir Davidson,[1] and Hui Cao[2,*]

[1] *Department of Physics of Complex Systems, Weizmann Institute of Science, Rehovot 7610001, Israel*
[2] *Department of Applied Physics, Yale University, New Haven, Connecticut 06520, USA*

S1. SPECKLE CONTRAST FROM THE ENTIRE LASING PULSE

For the speckle contrast analysis presented in Figure 2 of the main text, we set the total time window T to exclude any transient lasing behavior (e.g. spiking, relaxation oscillation) at the beginning of the lasing pulse and the intensity decay near the end of the lasing pulse. In Figure S1A, the vertical black dashed lines mark the time window of length $T \cong 50$ μs, within which lasing reaches a quasi steady state, and the speckle contrast is obtained as a function of the integration time τ.

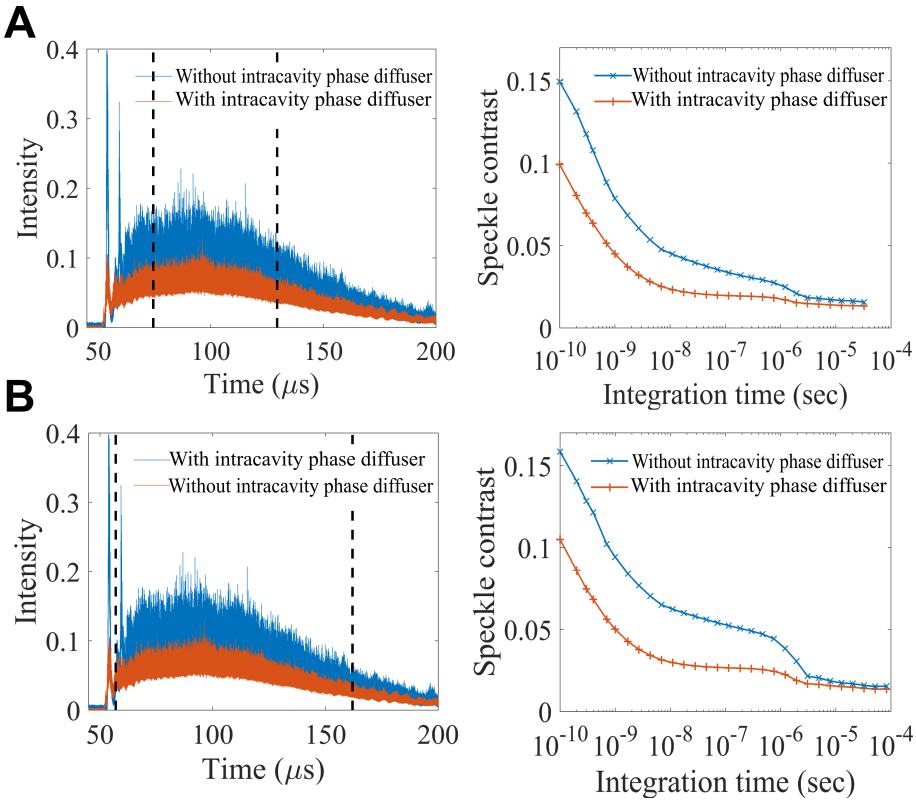

Figure S1: Effects of lasing transients on speckle contrast. (A) The measured time trace of emission intensity (left panel) and the speckle contrast (right panel) obtained from the middle part (marked by vertical black dashed lines) of the lasing pulse where quasi steady state is reached. (B) The time intensity trace (left) and the speckle contrast (right) obtained from almost the entire lasing pulse that is marked by the vertical black dashed lines. When the lasing transients are excluded, the speckle contrast is lower, especially at integration times between 10^{-8} to 10^{-6} sec.

---

‡ These authors contributed equally to this work.
* Corresponding author: hui.cao@yale.edu

Figure S1B shows the speckle contrast obtained with $T \cong 120$ µs, including the lasing transients. The speckle contrast decreases with increasing τ, similar to the case where the lasing transients are excluded. However, the speckle contrast is higher, especially at integration times between 10^{-8} to 10^{-6} sec, due to additional fluctuations of emission intensity at the beginning of the lasing pulse.

S2. SPECKLE CONTRAST AT TWO DIFFERENT PUMP VALUES

We measure the speckle contrast at different pump levels of the DCL. In the main text (Figure 2A), we show the speckle contrast measured at three times of the lasing threshold $P \approx 3P_{\text{th}}$ (also shown in Figure S2A). In Figure S2B we present the data measured at a lower pump level $P \approx 2P_{\text{th}}$. Since less transverse modes lase at a lower pump level, the speckle contrast is higher at any integration time, with and without the intracavity phase diffuser. However, the speckle contrast reduction by the intracavity phase diffuser is greater at the lower pump level. Lasing transient processes such as temporal spiking and relaxation oscillation last for a longer time at the lower pump level and that results in an increase of the speckle contrast. The intracavity phase diffuser reduces the quality factor of most lasing modes, and shortens the transient process. Thus, within the time window for the speckle analysis, the effect of lasing transients is weaker. This fact is, at least partly, responsible for the greater reduction of speckle contrast at a lower pump level.

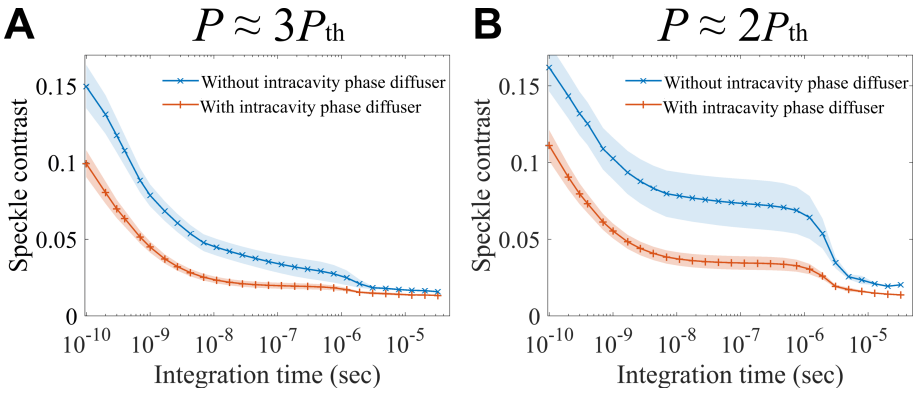

Figure S2: Speckle contrast as a function of the integration time, both without and with the intracavity phase diffuser in the DCL, at two pump levels. (A) $P \approx 3P_{\text{th}}$ (as in Figure 2 in the main text). (B) $P \approx 2P_{\text{th}}$. While the speckle contrast is higher at a lower pump level, the reduction of the speckle contrast by the intracavity phase diffuser is greater.