2.2. Observing the Network Dynamics

![Figure 2.2: Examples of experimentally measured time series (a), (c) and $V_1$ vs $V_2$ plots (b), (d) for the two oscillators: Oscillator 1 (blue line), Oscillator 2 (green line). (a),(b) In-phase oscillations and (c),(d) Anti-phase oscillations are exemplified in the figures. The MZMs are biased at $-\pi/4$ for a negative round trip gain.](image)

oscillators separately. If all the parameters are matched, we observe two identical sinusoidal waves with equal amplitudes and periods that are not phase-locked. The two waves wander along the screen and the phase difference between the two signals varies linearly with time.

### 2.2.2 Types of Correlated Oscillations

While the case of positive round-trip gain ($\phi = \pi/4$) and negative round-trip gain ($\phi = -\pi/4$) both exhibit oscillatory dynamics, it is important to notice that their oscillation frequencies are very different. When the MZMs are biased at $\pi/4$, the frequency of oscillations is observed to be 217 kHz. In contrast, when biased at $-\pi/4$, the frequency of oscillations is 44 MHz. By comparing our oscillations period with the delay, it is clear that the dynamics of the oscillators for the negative round trip gain with period 22.3 ns is on the timescale of the delay $\tau_f = 54.65$ ns, while for positive round trip gain, the timescale of the dynamics with period 4.6 $\mu$s is much greater than the timescale of the delay $\tau_f = 54.65$ ns. Therefore, we expect that coupling the two oscillators with delays comparative in length to the self-feedback delay will produce very different synchronization dynamics for the positive and negative gain cases. Therefore, we study the cases when the MZMs are biased at $\phi = \pi/4$ and...