

Fig. 6. Repeated spatial patterns and spatiotemporal sequences occurred frequently in the network after learning. (a) Raster plot before learning. When the repeated patterns in a test block of 50,000 steps were colored, it was found that no pattern occurred more than once in this short raster plot before learning. (b) Raster plot after learning. Several patterns appeared multiple times in the raster plot after learning. The repeated patterns are indicated by consistently colored circles and connected by lines.



Fig. 7. (a1) Raster plot before learning. Individual bursts in the spontaneous activity are indicated by different colors. The bursts before learning were short and frequently interrupted by steps without firing. (a2) Raster plot after learning. The bursts after learning had much longer durations than before learning. (b) Size distribution of avalanches. The black line corresponds to a slope of -1.5.

Coloring repeated patterns consisting of ≥ 3 firing neurons in raster plots of the network, we found that there are few repeated patterns in the activity of the network before optimization. Colored patterns in Fig. 6(a) did not occur twice in this short raster plot of 250 steps and were repeated later. Thus, there are few repeated patterns in the network activity before learning. However, the number of repeated patterns increased after learning (Fig. 6(b)). Several patterns were repeated in a sample of 250 steps as seen in Fig. 6(b), where the repeated patterns are indicated by consistently colored circles and connected by lines. For example, the purple pattern consisting of firings of neurons 8, 12, 29, and 49 (indicated by arrows) occurs four times (t = 4, 9, 34, 119, and 230) in this raster plot. Moreover, some patterns appeared to constitute repeated sequences. For example, sequence A, composed of the magenta, orange, and purple patterns, appears three times in Fig. 6(b). This indicates that the present algorithm embeds not only repeated patterns but also repeated sequences of firings into the network structure as a result of the optimization. This result is consistent with experimental results suggesting that the neuronal activity in our brain consists not of uncorrelated firings, but of repeated patterns and sequences of firings.

In the optimized network, when a pattern in a sequence