data, below which is the output of the α-tracker applied to the unfiltered data. Filtered output symbols 1 and 2 are both shown in black. Both plots are raster files taken directly from the computer screen, with an image resolution considerably coarser than the cell size: a single pixel covers approximately 3 spatial cells and 33 time steps. Because of this, the unfiltered data appears as a wash of randomly distributed pixels. The filtered plot, on the other hand, clearly shows the long-lived αs moving against a white background. The effective dynamics at this level is of stable α particles apparently undergoing a sort of statistical "repulsion" mediated by the hidden γs. This is somewhat analogous to Brownian motion of the α particles. At early times, we see a few annihilative collisions between adjacent αs that draw too close to each other. These collisions are the cause of the decay in the number of αs observed in fig. 12. After this transient period, the number of αs in fig. 13 remains constant and they remain roughly equidistant as they wander about within a close neighborhood. If we were to continue tracking the evolution of the system, we would see occasional α-α collisions occur at increasingly long intervals, until finite lattice size effects came into play.

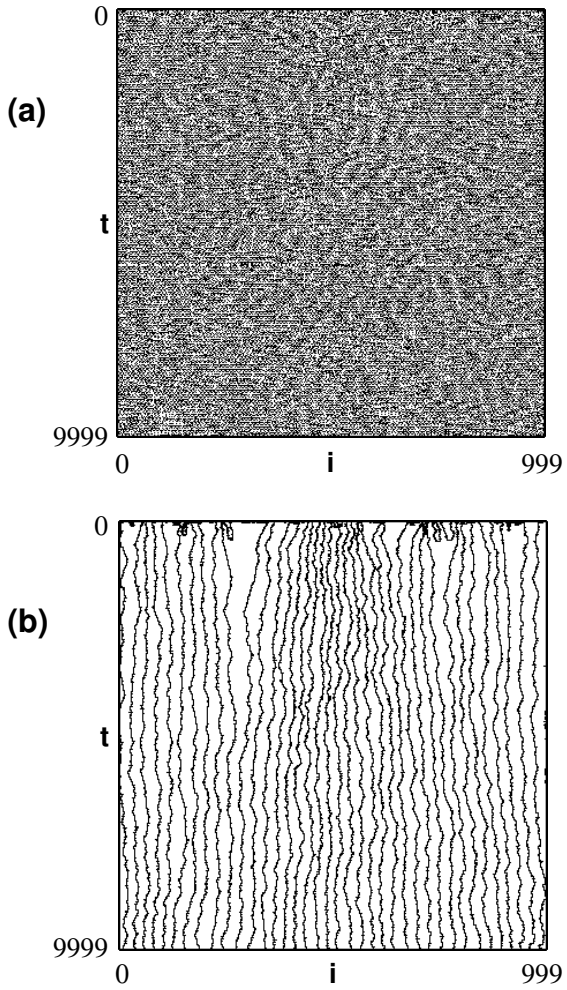

Figure 13. Substantially larger space-time diagrams of ECA 54; each diagram contains 10^7 space-time cells. (a) Unfiltered space-time diagram. (b) Same space-time diagram filtered with the α-tracker described in the text. These figures are raster files taken directly from a moderate resolution computer screen, with an image resolution that is considerably coarser than the cell size. The importance of domain filtering for visualization is especially obvious here. The filtering effects a data compression ratio of about 10^3.

6. Secondary structures

Besides the primary domain and fundamental particles, ECA 54 supports a large number of secondary structures, some having the domain and particles as building blocks, some not describable at the domain/particle level. This section presents a gallery of a few of these. Our goal at present is not to effect an exhaustive description of patterns arising in ECA 54, but rather to show how the computational mechanics analysis of the system facilitates their discovery and description.

ECA 54 possesses a number of regular domains other than Λ^0_{54}. The simplest of these is the language 0^*, consisting of all blocks of consecutive 0s. This language is obviously a domain of all CA that map the all-zeros neighborhood $\eta = 0...0$ to 0. But in ECA 54, as in most such CA, 0^* is unstable. Other easily identified domains in ECA 54 consist of multiple isolated particles of a single type separated by domain regions—for example, the pattern consisting of isolated γ^+ particles moving against a background of Λ^0_{54} is a domain. Using notation borrowed from regular expressions, we may write this domain language as $(\Lambda_{54} + \gamma^+)^*$. Other similar domains include $(\Lambda_{54} + \gamma^-)^*$, $(\Lambda_{54} + \alpha)^*$,$(\Lambda_{54} + \beta)^*$, and $(\Lambda_{54} + \alpha + \beta)^*$. This last should be understood to mean patterns containing both isolated αs and isolated βs; both types of particle may coexist without interact-