CLAIMS

1. An ion manipulation device comprising:

a first region configured to receive an ion packet comprising a plurality of ions and to separate the plurality of ions into one or more first region ion sub-packets having respective peak widths;

a second region separate from the first region, the second region configured to:

receive a first ion sub-packet of the one or more first region ion sub-packets, in which the first ion sub-packet comprises a first portion of the plurality of ions of the ion packet, and

generate an electric field waveform traveling along a first direction and having a varying duty cycle, the electric field waveform configured to drive the received first ion sub-packet along the first direction and generate a compressed ion sub-packet from the first ion sub-packet.

2. An ion manipulation device according to Claim 1, in which the electric field waveform travels from a first sub-region of the second region to a second sub-region of the second region, in which the varying duty cycle of the electric field waveform changes from a first duty cycle in the first sub-region to a second duty cycle in the second sub-region.

3. An ion manipulation device according to Claim 2, in which change in the duty cycle from the first duty cycle to the second duty cycle is configured to generate the compressed ion sub-packet in the second sub-region from the first ion sub-packet in the first sub-region.

4. An ion manipulation device according to Claim 2, in which the second region is further configured to receive a second ion sub-packet of the one or more first region ion sub-packets in which the second ion sub-packet comprises a second portion of the plurality of ions of the ion packet, and merge the second ion sub-packet into the compressed ion sub-packet.

5. An ion manipulation device according to Claim 4, in which the first ion sub-packet has a first temporal duration, the second ion sub-packet has a second temporal duration and the compressed ion sub-packet has a third temporal duration.

6. An ion manipulation device according to Claim 5, in which the third temporal duration is smaller than the first temporal duration.

7. An ion manipulation device according to Claim 4, in which the first ion sub-packet has a first spatial pulse length, the second ion sub-packet has a second spatial pulse length and the compressed ion sub-packet has a third spatial pulse length.

8. An ion manipulation device according to Claim 7, in which the third spatial pulse length is smaller than the first spatial pulse length.

9. An ion manipulation device according to Claim 2, in which the electric field waveform changes from the first duty cycle to a second duty cycle at an interface between the first sub-region and second sub-region.

10. An ion manipulation device according to Claim 1, in which a second direction of propagation of the ion packet in the first region is orthogonal to the first direction of propagation of the received first ion sub-packet in the second region.

11. An ion manipulation device according to Claim 1, in which a second direction of propagation of the ion packet in the first region is parallel to the first direction of propagation of the received first ion sub-packet in the second region.

12. An ion manipulation device according to Claim 1, in which a second direction of propagation of the ion packet in the first region and the first direction of propagation of the received first ion sub-packet in the second region are aligned at an angle ranging from about 0 degrees to about 359 degrees.

13. An ion manipulation device according to Claim 1, in which the compressed ion sub-packet generated from the first ion sub-packet has a narrower peak width than the first ion sub-packet based on the varying duty cycle.

14. A method comprising:

receiving, by a first region of an ion manipulation apparatus, an ion packet comprising a plurality of ions;

generating, in the first region, an electric field waveform configured to separate the plurality of ions into one or more first region ion sub-packets having respective peak widths;

receiving, by a second region of the ion manipulation apparatus, a first ion sub-packet of the one or more first region ion sub-packets in which the first ion sub-packet comprises

a first portion of the plurality of ions of the ion packet, in which the second region is separate from the first region; and

generating, in the second region, an electric field waveform traveling along a first direction and having a varying duty cycle, the electric field waveform configured to drive the received first ion sub-packet along the first direction and generate a compressed ion sub-packet from the first ion sub-packet.

15. A method according to Claim 14, in which the electric field waveform travels from a first sub-region of the second region to a second sub-region of the second region, in which the varying duty cycle of the electric field waveform changes from a first duty cycle in the first sub-region to a second duty cycle in the second sub-region.

16. A method according to Claim 15, in which change in the duty cycle from the first duty cycle to the second duty cycle is configured to generate the compressed ion sub-packet in the second sub-region from the first ion sub-packet in the first sub-region.

17. A method according to Claim 15, further comprising:

receiving, by the second region, a second ion sub-packet of the one or more first region ion sub-packets in which the second ion sub-packet comprises a second portion of the plurality of ions of the ion packet, and

merging the second ion sub-packet into the compressed ion sub-packet.

18. A method according to Claim 17, in which the first ion sub-packet has a first temporal duration, the second ion sub-packet has a second temporal duration and the compressed ion sub-packet has a third temporal duration.

19. A method according to Claim 17, in which the first ion sub-packet has a first spatial pulse length, the second ion sub-packet has a second spatial pulse length and the compressed ion sub-packet has a third spatial pulse length.

20. A method according to Claim 14, in which a second direction of propagation of the ion packet in the first region is orthogonal to the first direction of propagation of the received first ion sub-packet in the second region.

21. A method according to Claim 14, in which a second direction of propagation of the ion packet in the first region is parallel to the first direction of propagation of the received first ion sub-packet in the second region.

22. A method according to Claim 14, in which the compressed ion sub-packet generated from the first ion sub-packet has a narrower peak width than the first ion sub-packet based on the varying duty cycle.

23. An ion manipulation apparatus comprising:

a first region configured to receive an ion packet comprising a plurality of ions;

a second region separate from the first region, the second region configured to:

receive a first ion sub-packet comprising a first portion of the plurality of ions of the ion packet, and

generate an electric field waveform traveling along a first direction and having a varying duty cycle, the electric field waveform configured to drive the received first ion sub-packet along the first direction and generate a compressed ion sub-packet from the first ion sub-packet;

in which the electric field waveform travels from a first sub-region of the second region to a second sub-region of the second region, in which the varying duty cycle of the electric field waveform changes from a first duty cycle in the first sub-region to a second duty cycle in the second sub-region;

in which the second region is further configured to receive a second ion sub-packet comprising a second portion of the plurality of ions of the ion packet, and merge the second ion sub-packet into the compressed ion sub-packet.