CLAIMS

What is claimed is:

1. A method for generating and maintaining a magnetic field with a field reversed configuration (FRC) comprising the steps of:

merging first and second spheromak plasmas and forming an FRC about the merged plasma in a confinement chamber, and

maintaining the FRC at or about a constant value without decay by injecting beams of fast neutral atoms from neutral beam injectors into the FRC plasma at an angle towards the mid-plane of the confinement chamber.

2. The method of claim 1 wherein the step of the forming the FRC includes injecting spheromak plasmas from opposing first and second spheromak injectors towards the mid-plane of the chamber and merging the spheromak plasmas to form the FRC.

3. The method of claim 2 wherein the step of merging spheromak plasmas and forming the FRC plasma includes counter-helicity spheromak merging of the spheromak plasmas injected into the confinement chamber from the first and second spheromak injectors.

4. The method of claims 2 and 3 wherein the first and second spheromak injectors comprise a magnetized coaxial plasma gun (MCPG).

5. The method of claims 2 through 4 wherein the first and second spheromak injectors include an iron-core bias-coil system.

6. The method of claim 5 wherein the iron-core of the iron-core bias-coil system is cast iron with magnetic permeability of about 250.

7. The method of claim 5 wherein the iron-core of the iron-core bias-coil system is about 99.9 % Fe with magnetic permeability equal to or greater than about 200,000.

8. The method of claims 2 through 7 further comprising separately controlling the first and second spheromak injectors.

9. The method of claim 8 wherein the spheromak plasma ejected from the first spheromak injector is different from the spheromak plasma ejected from the second spheromak.

10. The method of claims 2 through 9 further comprising refueling the FRC plasma with one or more spheromak plasmas from one or more of the first and second spheromak injectors along a geometrical axis of the confinement chamber.

11. The method of claim 10 wherein the step of refueling includes multi-pulse injecting one or more spheromak plasmas into the FRC plasma from one or more of the first and second spheromak injectors.

12. The method of claims 2 through 9 further comprising forming and injecting multi-pulsed spheromaks into the FRC plasma.

13. The method of claims 1 through 12 wherein the step of injecting beams of fast neutral atoms includes one of the step of tuning the beam energies of the plurality of neutral beams between a first beam energy and a second beam energy, wherein the second beam energy differs from the first beam energy, or the step of tuning the beam energies of the plurality of neutral beams between a first beam energy and a second beam energy, wherein the second beam energy differs from the first beam energy, and wherein the second beam energy is higher than the first beam energy, or the step of tuning the beam energies of the plurality of neutral beams between a first beam energy and a second beam energy, wherein the second beam energy differs from the first beam energy, and wherein the plurality of neutral beams switch between the first and second beam energies during the duration of an injection shot.

14. The method of claims 1 through 13 further comprising generating a magnetic field within the chamber with quasi-dc coils extending about the chamber with quasi-dc coils extending about the chamber.

15. The method of claim 14 further comprising the step of guiding magnetic flux surfaces of the FRC into divertors coupled to the ends of the confinement chamber.

16. The methods of claim 15 further comprising the step of generating a magnetic field within the divertors with quasi-dc coils extending about the formation sections and diverters.

17. The method of claim 16 further comprising the step of generating a mirror magnetic field within opposing ends of the chamber with quasi-dc mirror coils extending about the opposing ends of the chamber.

18. The method of claims 14 through 17 further comprising the step of generating one of a magnetic dipole field and a magnetic quadrupole field within the chamber with saddle coils coupled to the chamber.

19. The method of claims 15 through 18 further comprising the step of conditioning the internal surfaces of the chamber and divertors with a gettering system.

20. The method of claim 19 wherein the gettering system includes one of a Titanium deposition system and a Lithium deposition system.

21. The method of claims 1 through 20 further comprising the step of controlling the radial electric field profile in an edge layer of the FRC plasma.

22. The method of claim 21 wherein the step of controlling the radial electric field profile in an edge layer of the FRC includes applying a distribution of electric potential to a group of open flux surfaces of the FRC with biasing electrodes.

23. The method of claims 2 through 22 further comprising one of injecting spheromak plasmas from the first and second spheromak injectors having magnetic flux greater than 20 mWb or injecting spheromak plasmas from the first and second spheromak injectors having magnetic flux greater than about 25-30 mWb.

24. A system for generating and maintaining a magnetic field with a field reversed configuration (FRC) comprising

a confinement chamber,

first and second divertors coupled to the confinement chamber,

first and second diametrically opposed spheromak injectors coupled to the first and second divertors for generating a spheromak plasma and translating the spheromak plasma toward a midplane of the confinement chamber,

a plurality of neutral atom beam injectors coupled to the confinement chamber and oriented to inject neutral atom beams toward a mid-plane of the confinement chamber at an angle less than normal to a longitudinal axis of the confinement chamber,

a magnetic system comprising a plurality of quasi-dc coils positioned around the confinement chamber and the first and second divertors, first and second set of quasi-dc mirror coils positioned between the confinement chamber and the first and second formation sections, and first and second mirror plugs position between the confinement chamber and the first and second divertors,

a gettering system coupled to the confinement chamber and the first and second divertors,

one or more biasing electrodes for electrically biasing open flux surface of a generated FRC, the one or more biasing electrodes being positioned within one or more of the confinement chamber and the first and second divertors, and

two or more saddle coils coupled to the confinement chamber.

25. A system for generating and maintaining a magnetic field with a field reversed configuration (FRC) comprising

a confinement chamber,

first and second divertors coupled to the confinement chamber,

first and second diametrically opposed spheromak injectors coupled to the first and second divertors,

one or more of a plurality of biasing electrodes and first and second mirror plugs, wherein the one or more biasing electrodes being positioned within one or more of the confinement chamber and the first and second divertors, and wherein the first and second mirror plugs being position between the confinement chamber and the first and second divertors,

a gettering system coupled to the confinement chamber and the first and second divertors,

a plurality of neutral atom beam injectors coupled to the confinement chamber and oriented angled toward the mid-plane of the confinement chamber, and

a magnetic system comprising a plurality of quasi-dc coils positioned around the confinement chamber and the first and second divertors, first and second set of quasi-dc mirror coils positioned between the confinement chamber,

wherein the system is configured to generate an FRC and maintain the FRC without decay while the neutral beams are injected into the plasma.

26. The system of claims 24 and 25 wherein the first and second spheromak injectors are configured to inject spheromak plasmas towards the mid-plane of the chamber to merge and form an FRC plasma.

27. The system of claim 26 wherein the first and second spheromak injectors are configured to form and inject into the confinement chamber first and second spheromak plasmas having counter-helicity.

28. The system of claims 24 through 27 wherein the first and second spheromak injectors comprise a magnetized coaxial plasma gun (MCPG).

29. The system of claims 24 through 27 wherein the first and second spheromak injectors include an iron-core bias-coil system.

30. The system of claim 29 wherein the iron-core of the iron-core bias-coil system is cast iron with magnetic permeability of about 250.

31. The system of claim 29 wherein the iron-core of the iron-core bias-coil system is about 99.9 % Fe with magnetic permeability equal to or greater than about 200,000.

32. The system of claims 24 through 27 wherein the first and second spheromak injectors are separately controllable.

33. The system of claim 32 wherein the first and second spheromak injectors are configured to multi-pulse inject more than one spheromak plasma into the confinement chamber.

34. The system of claims 24 through 33 wherein the plurality of neutral beams are adjustable between a first beam energy and a second beam energy, wherein the second beam energy differs from the first beam energy, and wherein the beam energies of the plurality of neutral beams are switchable between the first and second beam energies during the duration of an injection shot.

35. The system of claims 24 through 34 further comprising first and second diametrically opposed reversed-field-theta-pinch formation sections interposing the first and second divertors and the confinement chamber.

36. The system of claim 36 further comprising third and fourth divertors interposing the first and second diametrically opposed reversed-field-theta-pinch formation sections and the confinement chamber.