CLAIMS

What is claimed is:

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

a confinement chamber,

first and second diametrically opposed FRC formation sections coupled to the confinement chamber,

first and second divertors coupled to the first and second formation sections,

first and second axial plasma guns operably coupled to the first and second divertors, the first and second formation sections and 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 of 15° to 25° less than normal to a longitudinal axis of the confinement, and

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors, the magnetic system including first and second mirror plugs position between the first and second formation sections and the first and second divertors,

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.

.

2. The system of claim 1 wherein the magnetic system includes a plurality of quasi-dc coils axially spaced in positions along the confinement chamber, the first and second formation sections, and the first and second divertors.

3. The system of claim 2 wherein the magnetic system further comprises a first set of mirror coils positioned between the ends of the confinement chamber and the first and second formation sections.

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

a confinement chamber;

first and second diametrically opposed FRC formation sections coupled to the confinement chamber;

first and second divertors coupled to the first and second formation sections,

first and second axial plasma guns operably coupled to the first and second divertors, the first and second formation sections and 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 of 15° to 25° less than normal to a longitudinal axis of the confinement, and

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors, the magnetic system including a first set of mirror coils positioned between the ends of the confinement chamber and the first and second formation sections, first and second mirror plugs positioned between the first and second formation sections and the first and second divertors, and a plurality of quasi-dc coils axially spaced in positions along the confinement chamber, the first and second formation sections, and the first and second divertors, wherein the mirror plug comprises a second set of mirror

coils between each of the first and second formation sections and the first and second divertors,

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.

5. The system of claim 4 wherein the mirror plug further comprises a set of mirror plug coils wrapped around a constriction in the passageway between each of the first and second formation sections and the first and second divertors.

6. The system of claim 5 wherein the mirror plug coils are compact pulsed mirror coils.

7. The system of claim 1 further comprising a gettering system coupled to the confinement chamber and the first and second divertors.

8. The system of claim 1 further comprising 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, the first and second formation sections, and the first and second divertors.

9. The system of claim 1 further comprising two or more saddle coils coupled to the confinement chamber.

10. The system of claim 1 further comprising an ion pellet injector coupled to the confinement chamber.

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

a confinement chamber,

first and second diametrically opposed FRC formation sections coupled to the confinement chamber, wherein the first and second diametrically opposed FRC formation sections comprise modularized formation systems for generating an FRC and translating it toward a mid-plane of the confinement chamber,

first and second divertors coupled to the first and second formation sections,

first and second axial plasma guns operably coupled to the first and second divertors, the first and second formation sections and the confinement chamber,

a plurality of neutral atom beam injectors coupled to the confinement chamber and oriented to inject neutral atom beams toward the mid-plane of the confinement chamber at an angle of 15° to 25° less than normal to a longitudinal axis of the confinement, and

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors, the magnetic system including first and second mirror plugs positioned between the first and second formation sections and the first and second divertors,

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle

of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.

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

a confinement chamber,

first and second diametrically opposed FRC formation sections coupled to the confinement chamber,

first and second divertors coupled to the first and second formation sections,

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 of 15° to 25° less than normal to a longitudinal axis of the confinement,

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors, and

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

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.

13. The system of claim 12 wherein biasing electrodes includes one or more of one or more point electrodes positioned within the containment chamber to contact open field lines, a set of annular electrodes between the confinement chamber and the first and second formation sections to charge far-edge flux layers in an azimuthally symmetric fashion, and a plurality of concentric stacked electrodes positioned in the first and second divertors to charge multiple concentric flux layers.

14. The system of claim 12 wherein the magnetic system includes a plurality of quasi-dc coils axially spaced in positions along the confinement chamber, the first and second formation sections, and the first and second divertors.

15. The system of claim 14 wherein the magnetic system further comprises a first set of mirror coils positioned between the ends of the confinement chamber and the first and second formation sections.

16. The system of claim 15 wherein the magnetic system further comprises first and second mirror plugs, wherein the first and second sets of mirror plugs comprise a second set of mirror coils between each of the first and second formation sections and the first and second divertors.

17. The system of claim 16 wherein the first and second mirror plugs further comprise a set of mirror plug coils wrapped around a constriction in the passageway between each of the first and second formation sections and the first and second divertors.

18. The system of claim 17 wherein the mirror plug coils are compact pulsed mirror coils.

19. The system of claim 12 wherein the first and second formation sections comprises an elongate quartz tube.

20. The system of claim 19 wherein the formation section comprise pulsed power formation systems coupled to the quartz tube.

21. The system of claim 20 wherein the formation systems comprise a plurality of power and control units coupled to individual ones of a plurality of strap assemblies to energize a set of coils of the individual ones of the strap assemblies wrapped around the elongate tube of the first and second formation sections.

22. The system of claim 21 wherein individual ones of the plurality of power and control units comprising a trigger and control system.

23. The system of claim 22 wherein the trigger and control systems of the individual ones of the plurality of power and control units being synchronizable to enable static FRC formation wherein the FRC is formed and then injected or dynamic FRC formation wherein the FRC is formed and translated simultaneously.

24. The system of claim 12 wherein the plurality of neutral atom beam injectors are oriented with an injection path tangential to the FRC with a target trapping zone within separatrix of the FRC.

25. The system of claim 24 further comprising an ion pellet injector coupled to the confinement chamber.

26. The system of claim 12 further comprising two or more saddle coils coupled to the confinement chamber.

27. The system of claim 12 further comprising a gettering system coupled to the confinement chamber and the first and second divertors.

28. The system of claim 12 further comprising first and second axial plasma guns operably coupled to the first and second divertors, the first and second formation sections and the confinement chamber.

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

a confinement chamber,

first and second diametrically opposed FRC formation sections coupled to the confinement chamber,

first and second divertors coupled to the first and second formation sections,

first and second axial plasma guns operably coupled to the first and second divertors, the first and second formation sections and 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 of 15° to 25° less than normal to a longitudinal axis of the confinement, and

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors,

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.

30. The system of claim 29 wherein the individual ones of the first and second formation sections comprising an elongate tube and a pulsed power formation system coupled to the elongate tube.

31. The system of claim 30 wherein the formation systems comprise a plurality of power and control units coupled to individual ones of a plurality of strap assemblies to energize

a set of coils of the individual ones of the strap assemblies wrapped around the elongate tube of the first and second formation sections.

32. The system of claim 31 wherein individual ones of the plurality of power and control units comprising a trigger and control system.

33. The system of claim 32 wherein the trigger and control systems of the individual ones of the plurality of power and control units being synchronizable to enable static FRC formation wherein the FRC is formed and then injected or dynamic FRC formation wherein the FRC is formed and translated simultaneously.

34. The system of claim 29 further comprising one or more biasing electrodes for electrically biasing open flux surfaces of a generated FRC.

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

a confinement chamber,

first and second diametrically opposed FRC formation sections coupled to the confinement chamber,

first and second divertors coupled to the first and second formation sections,

first and second axial plasma guns operably coupled to the first and second divertors, the first and second formation sections and 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 of 15° to 25° less than normal to a longitudinal axis of the confinement,

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors, and

one or more biasing electrodes for electrically biasing open flux surfaces of a generated FRC, wherein the one or more biasing electrodes include one or more of one or more point electrodes positioned within the containment chamber to contact open field lines, a set of annular electrodes between the confinement chamber and the first and second formation sections to charge far-edge flux layers in an azimuthally symmetric fashion, a plurality of concentric stacked electrodes positioned in the first and second divertors to charge multiple concentric flux layers, and anodes of the plasma guns to intercept open flux,

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.

36. The system of claim 35 wherein the magnetic system includes a plurality of quasi-dc coils axially spaced in positions along the confinement chamber, the first and second formation sections, and the first and second divertors, and a first set of mirror coils positioned between the ends of the confinement chamber and the first and second formation sections.

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

a confinement chamber,

first and second diametrically opposed FRC formation sections coupled to the confinement chamber,

first and second divertors coupled to the first and second formation sections,

first and second axial plasma guns operably coupled to the first and second divertors, the first and second formation sections and 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 of 15° to 25° less than normal to a longitudinal axis of the confinement, and

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors, wherein the magnetic system includes a plurality of quasi-dc coils axially spaced in positions along the confinement chamber, the first and second formation sections, and the first and second divertors, a first set of mirror coils positioned between the ends of the confinement chamber and the first and second formation sections, and first and second mirror plugs, wherein comprises a second set of mirror coils between each of the first and second formation sections and the first and second divertors,

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.

38. The system of claim 37 wherein the mirror plug further comprises a set of compact pulsed mirror plug coils wrapped around a constriction in the passageway between each of the first and second formation sections and the first and second divertors.

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

a confinement chamber,

first and second diametrically opposed FRC formation sections coupled to the confinement chamber,

first and second divertors coupled to the first and second formation sections,

first and second axial plasma guns operably coupled to the first and second divertors, the first and second formation sections and 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 of 15° to 25° less than normal to a longitudinal axis of the confinement, wherein the plurality of neutral atom beam injectors are oriented with an injection path tangential to the FRC with a target trapping zone within a separatrix of the FRC, and

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors,

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.

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

a confinement chamber,

first and second diametrically opposed FRC formation sections coupled to the confinement chamber,

first and second divertors coupled to the first and second formation sections,

first and second axial plasma guns operably coupled to the first and second divertors, the first and second formation sections and 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 of 15° to 25° less than normal to a longitudinal axis of the confinement,

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors, and an ion pellet injector coupled to the confinement chamber,

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.

41. The system of claim 40 further comprising two or more saddle coils coupled to the confinement chamber.

42. The system of claim 40 further comprising a gettering system configured to coat plasma facing surfaces of the confinement chamber and the first and second divertors with a layer of gettering material.

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

a confinement chamber,

first and second diametrically opposed FRC formation sections coupled to the confinement chamber,

first and second divertors coupled to the first and second formation sections,

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 of 15° to 25° less than normal to a longitudinal axis of the confinement,

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors,

a gettering system configured to coat plasma facing surfaces of the confinement chamber and the first and second divertors with a layer of gettering material, and

a set of compact pulsed mirror coils wrapped around a constriction in the passageway between each of the first and second formation sections and the first and second divertors,

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.

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

a confinement chamber,

first and second diametrically opposed FRC formation sections coupled to the confinement chamber,

first and second divertors coupled to the first and second formation sections,

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 of 15° to 25° less than normal to a longitudinal axis of the confinement,

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors, the magnetic system comprising two or more saddle coils coupled to the confinement chamber on each side of the mid-plane of the confinement chamber, wherein the system further comprising first and second axial plasma guns operably coupled to the first and second divertors, the first and second formation sections and the confinement chamber,

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.

45. The system of claim 44 wherein the individual ones of the first and second formation sections comprising an elongate tube and a pulsed power formation system coupled to the elongate tube.

46. The system of claim 44 further comprising one or more biasing electrodes for electrically biasing open flux surfaces of a generated FRC.

47. The system of claim 44 wherein the magnetic system includes a plurality of quasi-dc coils axially spaced in positions along the confinement chamber, the first and second formation sections, and the first and second divertors, a first set of mirror coils positioned between the ends of the confinement chamber and the first and second formation sections,

and a second set of mirror coils between each of the first and second formation sections and the first and second divertors.

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

a confinement chamber,

first and second diametrically opposed FRC formation sections coupled to the confinement chamber,

first and second divertors coupled to the first and second formation sections,

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 of 15° to 25° less than normal to a longitudinal axis of the confinement,

a magnetic system coupled to the confinement chamber, the first and second formation sections, and the first and second divertors, the magnetic system comprising two or more saddle coils coupled to the confinement chamber on each side of the mid-plane of the confinement chamber, a plurality of quasi-dc coils axially spaced in positions along the confinement chamber, the first and second formation sections, and the first and second divertors, a first set of mirror coils positioned between the ends of the confinement chamber and the first and second formation sections, and a second set of mirror coils between each of the first and second formation sections and the first and second divertors, and

a set of compact pulsed mirror coils wrapped around a constriction in the passageway between each of the first and second formation sections and the first and second divertors,

wherein upon formation by the system of an FRC within the confinement chamber of the system, the FRC being maintainable by the system in spaced relation to the wall of the confinement chamber and at or about a constant value without decay while neutral atom

beams are injected from the plurality of neutral atom beam injectors into the FRC at an angle of 15° to 25° less than normal to the longitudinal axis of the confinement chamber and towards the mid-plane of the confinement chamber.