enhancing diffusion of any particles is, thus, important to take advantage of the higher performance potential of these never-before explored advanced FRC concepts.

[0008] In light of the foregoing, it is, therefore, desirable to improve the confinement and stability of FRCs in order to use steady state FRCs as a pathway to a whole variety of applications including compact neutron sources (for medical isotope production, nuclear waste remediation, materials research, neutron radiography and tomography), compact photon sources (for chemical production and processing), mass separation and enrichment systems, and reactor cores for fusion of light nuclei for the future generation of energy.

SUMMARY

[0009] The present embodiments provided herein are directed to systems and methods that facilitate the formation and maintenance of new High Performance Field Reversed Configurations (FRCs). In accordance with this new High Performance FRC paradigm, the present system combines a host of novel ideas and means to dramatically improve FRC confinement of particles, energy and flux as well as provide stability control without negative side-effects.

[0009A] According to a first aspect, there is provided a method for generating and maintaining a magnetic field with a field reversed configuration (FRC) comprising the steps of forming an FRC about a 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 and injecting a compact toroid plasma into the FRC.

[0009B] According to a second aspect, there is provided 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, the formation section comprising modularized formation systems for generating an FRC and translating the FRC toward a midplane 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 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, the first and second formation sections, 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 first and second formation sections 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, the first and second formation sections, and the first and second divertors, two or more saddle coils coupled to the confinement chamber, anda CT injector coupled to the confinement chamber.

[0009C] According to the third aspect, there is provided 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, one or more of a plurality of plasma guns, one or more biasing electrodes and first and second mirror plugs, wherein the plurality of plasma guns includes 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 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, and wherein the first and second mirror plugs being position between the first and second formation sections 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 normal to the axis of the confinement chamber, a magnetic system comprising a plurality of quasi-dc coils positioned around the confinement chamber, the first and second formation sections, 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 a CT injector coupled to 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.

[0010] An FRC system provided herein includes a central confinement vessel surrounded by two diametrically opposed reversed-field-theta-pinch formation sections and, beyond the formation sections, two divertor chambers to control neutral density and impurity contamination. A magnetic system includes a series of quasi-dc coils that are situated at axial positions along the components of the FRC system, quasi-dc mirror coils between either end of the confinement chamber and the adjacent formation sections, and mirror plugs comprising compact quasi-dc mirror coils between each of the formation sections and divertors that produce additional guide fields to focus the magnetic flux surfaces towards the divertor. The formation sections include modular pulsed power

formation systems that enable FRCs to be formed in-situ and then accelerated and injected (=static formation) or formed and accelerated simultaneously (=dynamic formation).

[0011] The FRC system includes neutral atom beam injectors and a pellet injector. In one embodiment, beam injectors are angled to inject neutral particles towards the mid-plane. Having the beam injectors angled towards the mid-plane and with axial beam positions close to the mid-plane improves beam-plasma coupling, even as the FRC plasma shrinks or otherwise axially contracts during the injection period. Gettering systems are also included as well as axial plasma guns. Biasing electrodes are also provided for electrical biasing of open flux surfaces.

[0012] In operation, FRC global plasma parameters including plasma thermal energy, total particle numbers, plasma radius and length, as well as magnetic flux, are substantially sustainable without