optic resonator similar to Fabri-Perot cells. Such an optic resonator needs mirrors with very high reflectance and a powerful light source with a thin line, and all of the optic elements need to be tuned very precisely. For example, in a scheme considered by Kovari *[M. Kovari et al., Fusion Engineering and Design 85 (2010) 745-7511,* the reflectance of the mirrors is required to be not less than 99.96%, the total laser output power is required to be about 800 kW with output intensity of about 300W/cm^2, and the laser bandwidth is required to be less than 100 Hz. It is unlikely that such parameters could be realized together.

[0005] Therefore, it is desirable to provide a non-resonance photo-neutralizer.

SUMMARY

[0006] Embodiments provided herein are directed to systems and methods for a non-resonance photo-neutralizer for negative ion-based neutral beam injectors.

In an aspect, there is provided a non-resonance photo-neutralizer for neutral beam injectors comprising first and second mirrors having opposing mirror surfaces forming a photon trap, wherein the mirror surface of the first mirror is concave and the mirror surface of the second mirror is flat, wherein the first mirror comprises a mirror assembly including a central mirror and first and second outer mirrors coupled at a first end to the central mirror and extending axially from the central mirror toward a second end with the distance between the first and second outer mirrors and the second mirror decreasing from the first end to the second end of the first and second outer mirrors.

In another aspect, there is provided a negative ion based neutral beam injector comprising a negative ion source, and a non-resonance photo-neutralizer co-axially positioned with the negative ion source, wherein the photo-neutralizer including first and second mirrors having opposing mirror surfaces forming a photon trap, wherein the mirror surface of the first mirror is concave and the mirror surface of the second mirror is flat, wherein the first mirror comprises a mirror assembly including a central mirror and first and second outer mirrors coupled at a first end to the central mirror and extending axially from the central mirror toward a second end with the distance between the first and second outer mirrors and the second mirror decreasing from the first end to the second end of the first and second outer mirrors.

The non-resonance photo-neutralizer described herein is based on the principle of nonresonant photon accumulation, wherein the path of the photon becomes tangled and trapped in a certain space region, i.e., the photon trap. The trap is preferably formed as two smooth mirror surfaces facing each other with at least one surface being concave. In the simplest form, the trap is preferably elliptical in shape. A confinement region of the trap is a region near a family of normals that are common to both mirror surfaces of the trap. The photons with a sufficiently small angle of deviation from the nearest common normal are confined. Depending on specific conditions, the shape of the trap may be one of spherical, elliptical, cylindrical, toroidal, or a combination thereof.

WHAT IS CLAIMED IS:

1. A non-resonance photo-neutralizer for neutral beam injectors comprising

first and second mirrors having opposing mirror surfaces forming a photon trap, wherein the mirror surface of the first mirror is concave and the mirror surface of the second mirror is flat, wherein the first mirror comprises a mirror assembly including a central mirror and first and second outer mirrors coupled at a first end to the central mirror and extending axially from the central mirror toward a second end with the distance between the first and second outer mirrors and the second mirror decreasing from the first end to the second end of the first and second outer mirrors.

2. The photo-neutralizer of claim 1 wherein the photon trap comprises a confinement region adjacent a family of normals common to the mirror surfaces of the first and second mirrors.

3. The photo-neutralizer of claim 1 wherein the central mirror is cylindrically shaped and the outer mirrors are conically shaped.

4. The photo-neutralizer of claim 1 wherein the photon trap having a storage efficiency, P/P_{in}, of approximately 1000 with a mirror reflectance of $\boldsymbol{r}^2$=0.999 for the first and second mirrors, and wherein the storage efficiency is defined as $\boldsymbol{P}/\boldsymbol{P}_{in} \approx \frac{1}{1-\boldsymbol{r}^2} \approx 1000$.

5. A negative ion based neutral beam injector comprising

a negative ion source, and

a non-resonance photo-neutralizer co-axially positioned with the negative ion source, wherein the photo-neutralizer including first and second mirrors having opposing mirror surfaces forming a photon trap, wherein the mirror surface of the first mirror is concave and the mirror surface of the second mirror is flat, wherein the first mirror comprises a mirror assembly including a central mirror and first and second outer mirrors coupled at a first end to the central mirror and extending axially from the central mirror toward a second end with the distance between the first and second outer mirrors and the second mirror decreasing from the first end to the second end of the first and second outer mirrors.

6. The neutral beam injector of claim 5 wherein the photon trap comprises a confinement region adjacent a family of normals common to the first and second mirror surfaces.

7. The neutral beam injector of claim 5 wherein the central mirror is cylindrically shaped and the outer mirrors are conically shaped.

8. The neutral beam injector of claim 5 wherein the photon trap having a storage efficiency, P/P_{in}, of approximately 1000 with a mirror reflectance of $\boldsymbol{r}^2$=0.999 for the first and second mirrors, and wherein the storage efficiency is defined as $\boldsymbol{P}/\boldsymbol{P}_{in} \approx \frac{1}{1-\boldsymbol{r}^2} \approx 1000$.