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A System of Two Identical and Opposite Magnets Focusing Beam Charged Particles Passing Through Them

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Abstract : In this work, we use two magnets placed in front of the path of charged particles to obtain the best focusing of charged particles in both the horizontal and vertical planes. We trace the path of charged particles from the extraction region at the ion source, until reach to the target were traced. The process of tracing the path of charged particles is performed using matrices Transfer Matrix (R- Matrix) and. Beam Matrix□ □)in each region in which passing the charged particles, starting from the extraction region reaching to the target by describing the charged particle beams as phase space ellipse in both the horizontal and vertical planes. The ion beam described as phase space ellipse then study the behavior of beam at the edges of magnet with Identical and Opposite.

Keywords : Ion Beam Transport , Charged Particles Beam , Double Focusing , Magnet Deflector.

I. Introduction

A charged particle beam is a group of particles that have about the same kinetic energy and move in about the same direction. The theory of charged particle beams is much more than a tool to design machines, it is one of the richest and most active areas of classical physics. The study of charged particle beams, gives comprehensive understanding of applied electromagnetism and collective physics. Despite the practical importance and underlying unity of beam physics, the field has not yet achieved a strong identity like plasma physics [1].To guide a charged particle along a predefined path, magnetic fields could be used to deflect particles, as determined by the equilibrium of the centrifugal force and the Lorentz force. During the processes of transport, a charged particle interacts with static and dynamic electromagnetic fields. The Lorentz force is used to formulate the particle dynamics under the effect of these fields [2]. The type of magnet that used in this work is a C-magnet, this type produces homogeneous magnetic field that means, the magnetic flux is nearly equal along the beam path inside the bending magnet.

Also, the uniform magnet with non-zero angular entrance and exit pole edges.

The ion beam trajectory in the magnetic sector field is expressed by the product of the transfer matrices corresponding to each field. The bending magnet system may be divided into many regions. We use two magnet sectors to understand the behavior of charged particles beam passing through each one of the magnet sector. So we will study the effect of exit angle (□) on the double focusing of the ion beam when passing through two magnetic fields whereas the entrance (□), deflection (Φ) angles and the radius of curvature (□ o) are fixed [3,4,5].

II. Experimental Part

In the present work two magnets are Identical and Opposite in the deflected angles ($□_{M1}$ = $□_{M2}$ = 75^o) and opposite in the radius of curvature sign and with same value of the radius of curvature magnets ($□_{o\ M1}$ = - $□_{o\ M2}$ = 380 mm) and the value of magnet gap (g) equal to (40 mm) for two magnets. For study the effect of the exit angles (□) of the magnets on the double focusing of the ion beam in horizontal plane (x-plane) and vertical plane (y-plane). A computer program written in MATLAB language to tracing the path of charged particles beam within the system design. This program studies the movement of charged particles as a bunched beam and represents phase space ellipse for both horizontal and vertical planes. as indicate in figure (1) :

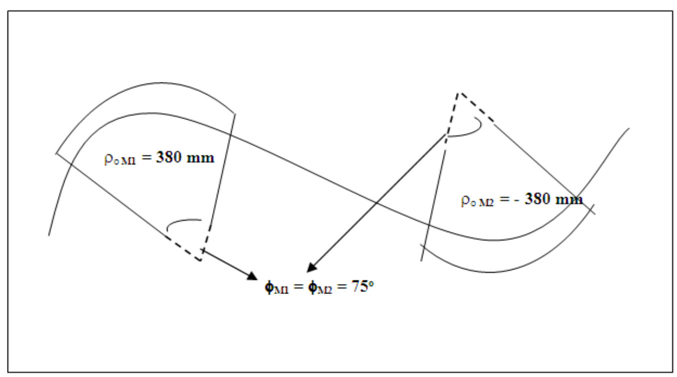

Figure 1 : Configuration Two Magnets Identical in the Deflected Angles and Opposite in the Radius of Curvature Signs.

From this figure one can note that, the path of the ion beam is change in the direction when the ion beam passing through the second magnet because the change of the radius of curvature sign. This lead to that the path of the ion beam is take account of the shape of the magnet.

For study the effect of the exit angles (□) on the double focusing of the ion beam in the horizontal and vertical planes.

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Horizontal Plane (x-Plane)

The effect of the exit angles for the first and second magnets on the beam envelope shown in figure (2).

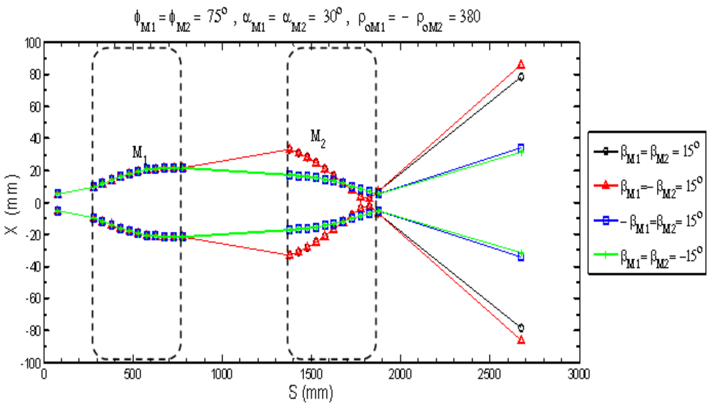

Figure (2) : The Beam Envelope in the Horizontal Plane.

From this figure illustrates that, in the first magnet when the exit angles are have negative sign appear focus action in the ion beam, while defocus in the ion beam appear when the exit angles have positive sign for the first magnet. The ion beam passing through the second magnet by the same of the entrance angles for the first magnet one can note that, for positive sign of the exit angles for the first magnet and the entrance angles for the second magnet have same value and sign obtained waist before it exit from the second magnet. When the ion beam exit from the second magnet, one can note the defocus action for all the beams whether the exit angles are positive sign or negative sign for the second magnet. In other word, when reversed the second magnet one can note have defocus for all the ion beams.

The phase space ellipse in the horizontal plane (x-plane) shown in figure(3). This figure illustrate the phase space ellipse in (x ,x') plane to the same of the entrance angles for the first and second magnets, and the exit angles of the first and second magnets once to equal value and the different of the sign. Also, from the same figure we can show the waist production at the end of the second magnet specially (3-c) and (3-d).

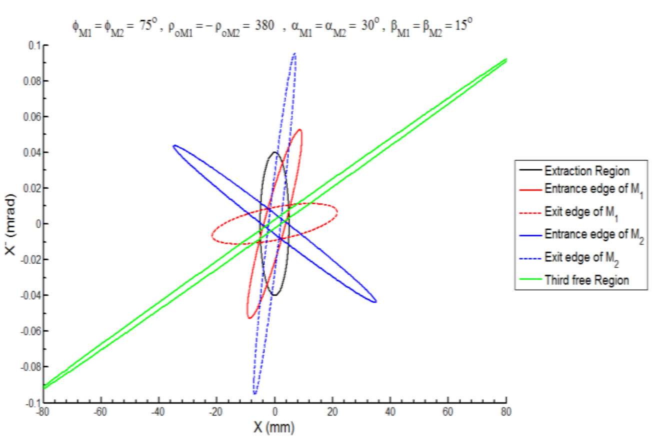

Figure 3 (a)

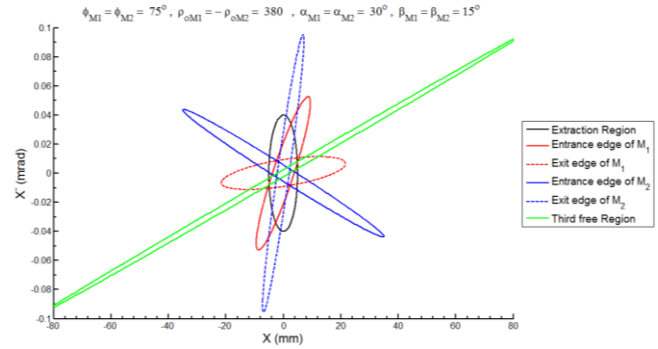

Figure 3 (b)

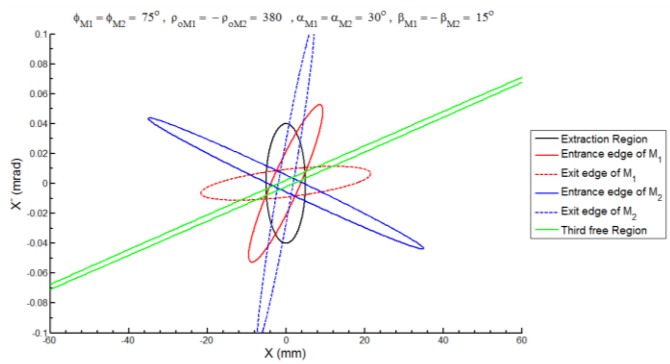

Figure 3 (c)

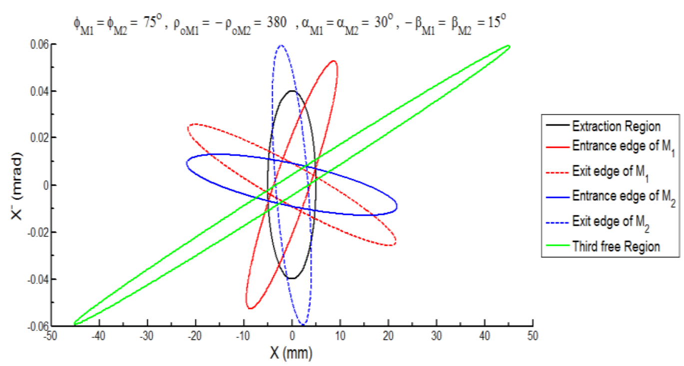

Figure 3 (d)

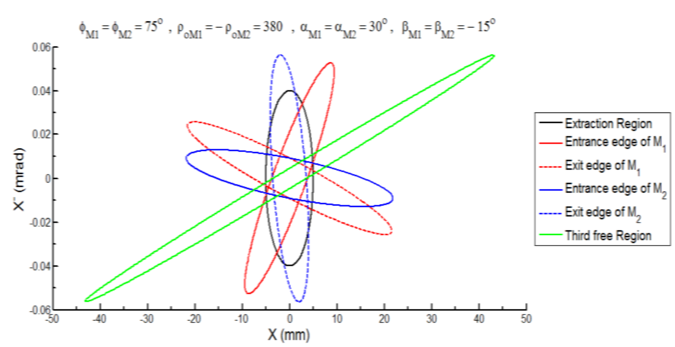

Figure 3 (e)

Figure3: The Phase Space Ellipse of Horizontal Plane.

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Vertical Plane (y-Plane) The effect of the exit angles for the first and second magnets on the beam envelope in the vertical plane when the second magnet is reversed shown in the figure (4) :

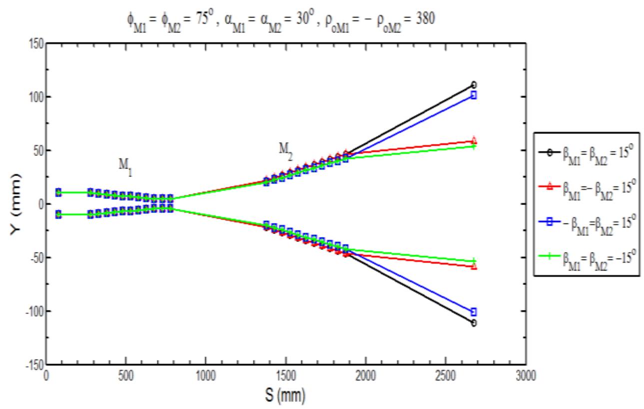

Figure 4 : The Beam Envelope in the Vertical Plane.

From this figure indicate that, the exit angles for the first magnet the positive and negative signs there is defocusing action of the ion beam, also the effect of the exit angles for the second magnet on the ion beam are the same as the effect of the exit angles for the first magnet. In other word, the effect of the exit angles for the second magnet have negative sign are more than the effect of the exit angles for the second magnet with positive sign.

Figure (5) shown the phase space ellipse in the vertical plane when the entrance angles have equal values with same sign for the first and second magnets and the exit angles once to equal value with different sign for the first and second magnets as the regions represented in the horizontal plane.

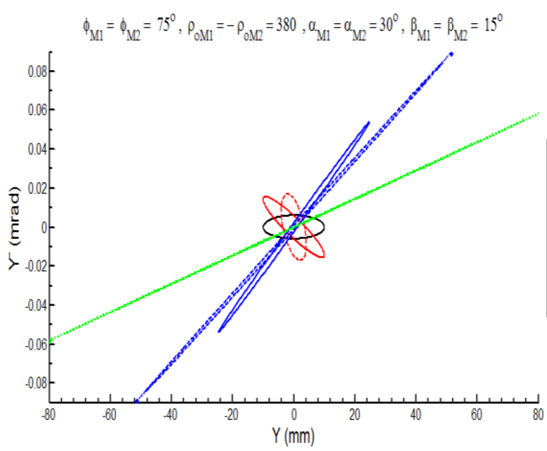

Figure 5 (a)

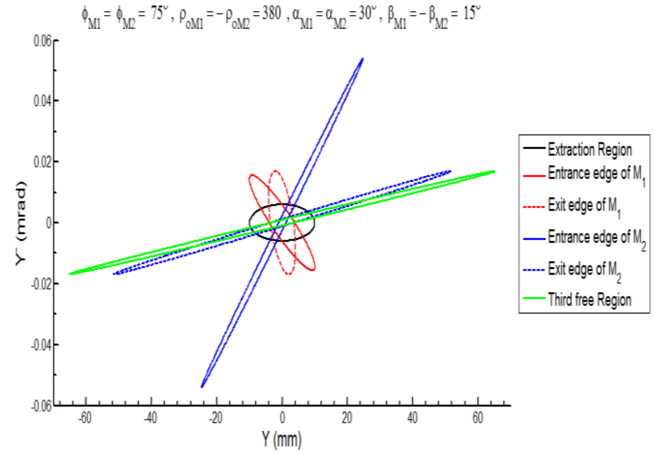

Figure 5 (b)

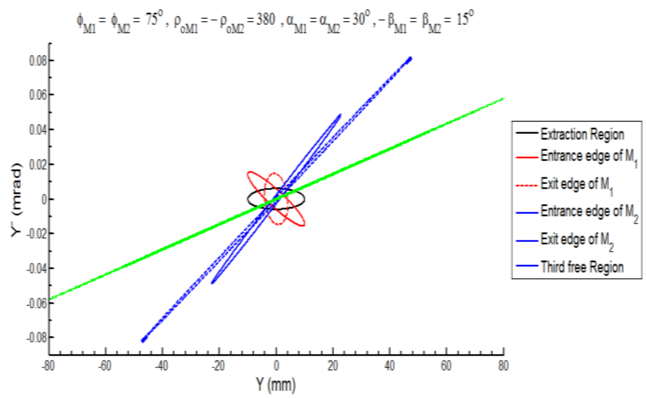

Figure 5 (c)

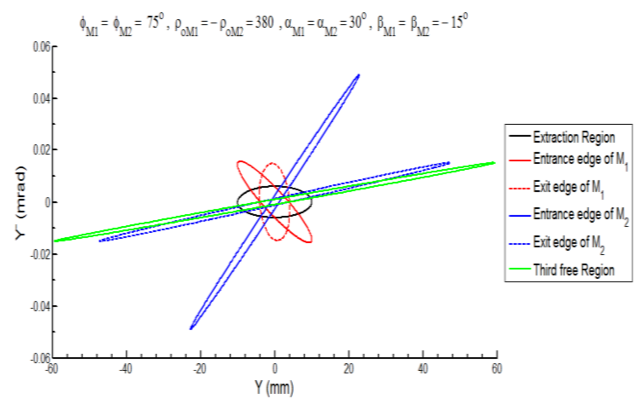

Figure 5 (d)

Figure 5: The phase space ellipse in the vertical plane.

III. Conclusions

When changing exit angles for the second magnet to study effect of this magnet. when the two magnets are identical and non-opposite we note the following : When the two magnets are identical and opposite we note that :

1. In horizontal plane.

when (M2 , + M2) the behavior of ion beam change from focusing to defocusing by decreasing the entrance angle and this changing increasing by increasing the exit angle.

when (M2 ,- M2) the behavior of ion beam change from focusing to defocusing by decreasing the entrance angle and this changing increasing by increasing the exit angle.

when (M2 , + M2) there is defocusing in the ion beam and this defocusing increasing by increasing value of exit angle.

when (M2 ,- M2) there is defocusing in the ion beam and this defocusing increasing by increasing value of exit angle.

2. In the vertical plane.

when (M2 , + M2) there is defocusing in the ion beam and this defocusing increasing by increasing the value of exit angle.

when (+   M2 ,- M2) there is defocusing in the ion beam and this defocusing increasing by increasing value of exit angle.

when (M2 , + M2) the ion beam change from defocusing to focusing and this focusing increasing by increasing value of exit angle.

when (M2 ,- M2) the behavior of ion beam changing from defocusing in the ion beam to focusing and this focusing increasing by increasing value of exit angle.

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