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Optimization of nanotube accelerator for proton beam generation
ナノチューブ加速器の工学的最適化シミュレーション

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Nanotube accelerator is proposed as one of the promising mechanism for the proton driver. We consider carbon nanotubes with fragments of low-Z materials are irradiated by an ultrashort intense laser to remove electrons. As a result, the nanotube and filled materials play the roles of the barrel and bullets of a gun, respectively, to produce highly collimated and quasimonoenergetic ion beams. In this research, we simulate to optimize the system structure assuming that the structure is axially symmetric and constructed by gathering 'ring plasma'.

1. Introduction
Ion acceleration driven by ultrashort intense laser pulses has been studied in the past decade. This technology is expected to apply to the following, cancer therapy, compact neutron sources, and ion-driven fast ignition.

Nanotube accelerator [1] (Fig.1) is expected as a new scheme in ion acceleration and can produce high-quality beams that are collimated and monoenergetic.

2. Objective
The dynamics of nanotube accelerator irradiated by ultrashort intense laser can be investigated by molecular dynamics method which take the two-body Coulomb interactions into account for all particles. But, the method need a long CPU time. In this research, we look at a symmetric system which can reduce the amount of calculation. By using the following model, we optimize the parameter of the nanotube accelerator such as collimation and quasimonoenergy to achieve high-quality beam.

3. Simulation model
We assume that the nanotube and the fragments of low-Z materials are axially symmetric in the cylindrical geometry. We assume that the proton generator is constructed by 'ring plasma' (Fig.2). Ring plasma consists of 2-dimensional circle which represent a group of ions. By calculating Coulomb interaction between each two rings, we can demonstrate the dynamics of nanotube accelerator irradiated by an ultrashort intense laser.

4. Conclusion
By assuming our ring model, we have simulated the dynamics of nanotube accelerator. By varying the aspect ratio of the nanotube or species of ions of low-Z materials, we have optimized such performance of nanotube accelerator as collimation and quasimonoenergy about proton beam.

Each aspect ratio about nanotube and species of ions of low-Z materials are 18:11 and 4:3 for length and diameter, respectively.

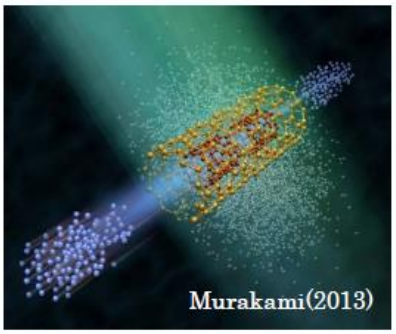

Fig.1. schematic view of nanotube accelerator

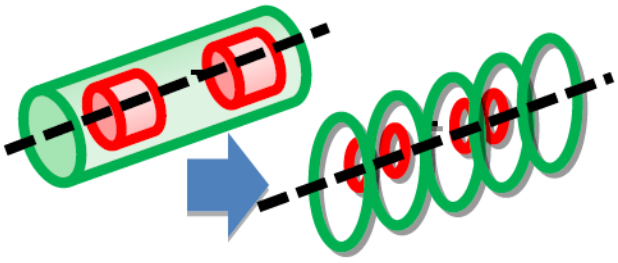

Fig.2. simulation model

5. Reference
[1] M.Murakami and M.Tanaka Appl. Phys. Lett. 102, 163101(2013)