Nuclear Science Research Facility
- Beams and Fundamental Reaction -

(1) http://www.scl.kyoto-u.ac.jp/~sakabe/index.html (2) http://carrack.kuicr.kyoto-u.ac.jp/

(1) Laser-matter interaction science

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(2) Astroparticle and atomic physics

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Scope of Research

(1) Laser-matter interaction science

Physics of matter in strong optical field created by powerful lasers is studied. With ultra-intense intense femtosecond laser, ionization and Coulomb explosion of large molecules and clusters, and high energy radiation (x-ray, electrons, ions) generation in plasmas are of our interest to open a new field of laser nuclear science.

(2) Astroparticle and atomic physics

Dark matter particles in the Universe are studied with quantum electronic methods: Search for a dark-matter candidate, axion, in the Universe with Rydberg atoms, and related characteristics of Rydberg atoms in external fields.

Research Activities (Year 2003)

Presentations

(1) Laser-matter interaction science

Anisotropic Coulomb explosion of Ar cluster induced by an intense femtosecond-laser pulse, S. Shimizu, M. Hirokane, M. Hashida, S. Okihara, Y. Izawa, S. Sakabe, International Symposium on Ultrafast Intense Laser Science 2: Propagation and Interaction, Quebec, Canada, 27 - 29 September.

Molecular deformation of benzene and fluorinated benzene in explosion processes induced by intense femtosecond-laser pulses, S. Shimizu, V. Zhakovskii, M. Murakami, T. Yatsuhashi, K. Nishihara, S. Sakabe, Y. Izawa, N. Nakashima, International Symposium on Ultrafast Intense Laser Science 2: Propagation and Interaction, Quebec, Canada, 27 - 29 September.

Femtosecond laser ablation of metals: characterization of new processing phenomenon and formation of nanostructures, M. Hashida, S. Nagashima, M. Fujita, M. Tsukamoto, M. Katto, and Y. Izawa, 9th Symposium on Microjoining and Assembly Technology in Electronics (Mate), Yokohama, Japan, 6 - 7 February.

Periodic structure of metals with femtosecond laser ablation, M. Hashida, M. Fujita, M. Tsukamoto, Y. Izawa, and A. F. Semerok, 2003 Conference on Lasers and Electro-Optics Europe (CLEO/Europe), Munich, Germany, 23 - 27 June.

(2) Astroparticle and atomic physics

Zerofield crossings in the pulsed field ionization under a rotating electric field, Shibata M, Kishimoto Y, Tada M, Yamada S, Kominato K, Haseyama T, Funahashi H, Yamamoto K, and Matsuki S, Autumn Meeting, Phys. Soc. Jpn.,

Topics

(1) Laser-matter interaction science

Generation of high energy protons from hydrogen clusters Coulomb-exploded by intense femtosecond laser pulses

Energy distributions of protons emitted from hydrogen clusters Coulomb-exploded by an intense femtosecond laser have been experimentally obtained. 10,000-hydrogen clusters were exploded to emit 8.1 keV protons under laser irradiation of intensity 6×10^{16} W/cm^2. The energy distributions are interpreted well by a spherical uniform cluster analytical model for the first time. The maximum energy of emitted protons can be characterized by cluster size and laser intensity. The laser intensity scale for the maximum proton energy, given by a spherical cluster Coulomb explosion model, is in fairly good agreement with the experimental results obtained at the laser intensity of 10^{16}-10^{17} W/cm^2 and also when extrapolated to the results of three dimensional particle simulations at 10^{20}-10^{21} W/cm^2.

Ion generation in a low-density plastic foam by interaction with intense femtosecond laser pulses

Energetic proton generation in low-density plastic (C_5H_{10}) foam by intense femtosecond laser pulse irradiation has been studied experimentally and numerically for the first time. Plastic foam was successful produced by a sol-gel method, achieving an average density of 10 mg/cm^3. The foam target was irradiated by 100-fs pulses of a laser intensity 1×10^{18} W/cm^2. A plateau structure extending up to 200 keV was observed in the energy distribution of protons generated from the foam target, with the plateau shape well explained by Coulomb explosion of lamella in the foam. The laser-foam interaction and ion generation were studied qualitatively by two-dimensional Particle-in-Cell (PIC) simulations, which indicated that energetic protons are mainly generated by the Coulomb explosion. From the results, the efficiency of energetic ion generation in a low-density foam target by Coulomb explosion is expected to be higher than in a gas-cluster target.

(2) Astroparticle and atomic physics

Zero-field crossing in the pulsed-field ionization processes under a rotating electric field

Rydberg atoms have been widely utilized for fundamental physics researches. In order to extend further the applicability of the Rydberg atoms in higher excited states[1], we developed new stringent schemes to selectively ionize highly excited Rydberg atoms by manipulating the ionization path in a Stark map[2]: In one of these schemes, zero-filed crossing during the course of the pulsed field ionization under a rotating electric field plays a key role for improving the selectivity. Underlying physics in these issues is the rotation of the state angular momentum due to the rotating electric field: Specifically with this rotation effect, the tunneling ionization process increases profoundly compared to the autoionization-like process. In Fig.1 shown is the fraction of the tunneling ionization in the n=112 manifold states of ^{85}Rb as a function of the applied transverse electric filed. Quantum theoretical predictions (solid line) reproduce fairly well the experimental results.

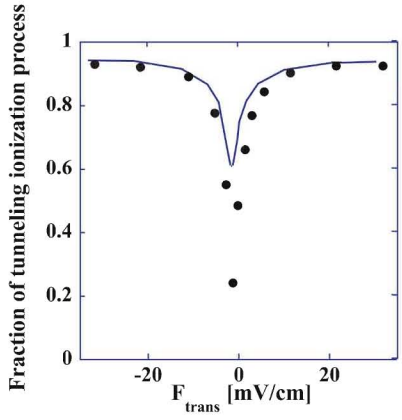

Fig.1 Fraction of the tunneling field ionization process as a function of the applied transverse electric field in the n=112 manifold states of Rb. The fraction increases abruptly with increasing transverse field, indicating a profound effect of the rotating electric field on the substate redistribution of the total angular momentum.

1. T. Haseyama *et al.*, Phys. Lett. A**317** (2003) 450.
2. M. Tada, *et al.*, Phys. Lett. A**303** (2002) 285;Y. Kishimoto *et al.*, Phys. Lett. A303 (2002) 279.

Okayama, 22 September.

Autoionization process in the highly excited Rydberg atoms of Rb, Yamada S, Kishimoto Y, Tada M, Shibata M, Kominato K, Haseyama T, Funahashi H, Yamamoto K, and Matsuki S, Autumn Meeting, Phys. Soc. Jpn., Okayama, 22 September.

Grants

Sakabe S, Fundamental Research on γ-ray laser with intense femtosecond lasers, Grant-in-Aid for Scientific Research (B)(2), 1 April 2003 - 31 March 2005.

Sakabe S, Research on Coulomb Explosion Dynamics of Cluster Molecules with intense lasers, Grant-in-Aid for Scientific Research Priority Areas (C), 1 April 2003 - 31 March 2004.