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学位論文名	Irradiation effect of Ortho deuterium for UCN source （超冷中性子源用オルソ重水素における放射線効果）
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論文内容の要旨

Production of ultra-cold neutrons (UCN) by a solid deuterium (sD_2) in the ortho state has been offered as one of the powerful UCN sources for fundamental physics research. However, since this type of UCN source is usually exposed to strong rasiations generated by a spallation target nearby, there may be a serious conversion from the ortho to para D_2, which eventually deteriorates the UCN source performance.

In the present work, the irradiation effect on the ortho sD_2 at 25 K (liquid phase) was experimentally investigated by the SINQ (Spallation Neutron Source) at PSI (Paul Scherrer Institute), Zürich, Switzerland and the 30-MeV Elactron LINAC at KURRI (Kyoto University Research Reactor Institute), Kumatori, Kyoto University.

In the former experiment, the ortho-D_2 fractions sampled from the SINQ moderator twice during few month were measured by means of the Raman spectroscopy with a 70-mW Ar ion laser, from which one can deduce information on the equilibrated ortho/para ratios determined from the competing processes between the ortho-to para-D_2 and vice versa.

In the latter experiment, the ortho-D_2 fractions sampled from the ortho-D_2 irradiated by Bremsstrahlung gamma-rays generated by the LINAC were measured also by means of the Raman spectroscopy with a 10-W Ar ion laser at Dept. of Physics, Kobe University. To investigate the ortho fractions varied with the radiation dose, absolute values of radiation dose were measured by using the foil activation analysis in cooperation with energy spectra of gamma-rays calculated with the Monte Carlo simulation, Geant4.

The experimental results were analyzed by solving the rate equations, in which conversion effects from the ortho- to para-D_2, and vice versa caused by complicated processes such as dissociations, recombination for relevant D_2 molecules, D atoms, D^+, D^- ions, and impure molecules playing in the D_2 sample were reasonably taken into account.

One of the striking results deduced from our measurement is that the conversion rate from the ortho- to

para-D_2 due to irradiation is larger by a factor 5 than the established value so far, which suggests participation of unknown conversion processes to explain our enhanced conversion rate. We propose a novel process relevant with D_3^+ ion as one of candidates for this enhancement.

According to our established model calculation, the ortho fraction is expected to be no serious effect on a realizable UCN density for the source planned at PSI.

論文審査の結果の要旨

中性子の電気双極子能率や半減期等の精度良い値は自然の対称性の検証、ニュートリノ世代数の決定等基礎物理研究に重要な情報を提供する。そのためこれら測定に有用な超冷中性子を大量生成する方法の開発が重要課題となっている。最近目覚しい進展を遂げつつある高強度陽子加速器で核破砕反応により生成される高強度中性子は超冷中性子生成に有用と期待されている。そこではオルソ固体重水素が有効な冷媒と期待されている。本論文はこの冷媒の超冷化能力に対する放射線の影響についてオルソ液体重水素を用い調べたものである。その結果、放射線効果によりオルソ状態からパラ状態への変換率は従来の予想値より4倍大きい事、しかし固体重水素による超冷中性子生成法利用により現在の最大量の300倍生成できる事を明らかにする結果を得た。これら結果は原子核物理にとり重要な結果であり博士（理学）の学位論文として十分価値あるものと認める。