

## Nuclear Science and Transmutation Research Division Astro-Glaciology Research Group

### 1. Abstract

Our Astro-Glaciology Laboratory promotes both experimental and theoretical studies to open up the new interdisciplinary research field of astro-glaciology, which combines astrophysics, astrochemistry, glaciology, and climate science.

On the experimental side, we measure isotopic and ionic concentrations in ice cores drilled at Dome Fuji station, Antarctica, in collaboration with the National Institute of Polar Research (NIPR, Tokyo). Here, the ice cores are time capsules which preserve atmospheric information of the past. In particular, the ice cores obtained around the Dome Fuji site are very unique, because they contain much more information on the stratosphere than any other ice cores obtained from elsewhere on Earth. This means that we have significant advantages in using Dome Fuji ice cores if we wish to study the Universe, since UV photons, gamma-rays, and high energy protons emitted by astronomical phenomena affect the stratosphere.

Our principal aim is thus to acquire and interpret information preserved in ice cores regarding:

- Signatures of past volcanic eruptions and solar cycles;
- Relationship between climate change and solar activity;
- Traces of past supernovae in our galaxy, in order to understand better the rate of galactic supernova explosions.

Moreover, we are promoting experimental projects on:

- Development of an automated laser melting sampler for analyzing ice cores with high depth resolution;
- Development of precise analytical techniques of high sensitivity for analyzing ice cores;
- The application of analytical methods for measuring isotopes in ice cores to archaeological artifacts;
- The evolution of molecules in space;

On the theoretical side, we are simulating numerically:

- Chemical effects of giant solar flares and supernovae on the Earth's atmosphere;
- The explosive and the *r*-process nucleosynthesis in core-collapse supernovae;

Combining our experimental evidence and theoretical simulations, we are promoting the researches mentioned above. These all will contribute to understanding relationships between the Universe and Earth. In particular, climate change is the most critical issue facing the world in the 21st century. It is also emphasized that the frequency of supernova explosions in our galaxy has not yet been fully understood, and it is the key to understand the *r*-process nucleosynthesis.

### Members

#### Director

Yuko MOTIZUKI

#### Senior Research Scientist

Yoichi NAKAI

#### Special Temporary Research Scientist

Kazuya TAKAHASHI

#### Technical Staff

Yu Vin SAHOO

#### Senior Visiting Scientists

Yasushige YANO (Nishina Memorial Foundation)  
Hideharu AKIYOSHI (National Institute for Environmental  
Studies)

Kunihiko KODERA (Meteorological Res. Inst.)

#### Visiting Scientists

Hisashi HAYAKAWA (Nagoya Univ.)  
Hideki MADOKORO (Mitsubishi Heavy Industries, Ltd.)

Kazuho HORIUCHI (Hiroshima Univ.)  
Akira HORI (Kitami Inst. of Tech.)

#### Visiting Technicians

Junya HIROSE (Fusion Tech. Co., Ltd.)

Yuma HASEBE (Denryoku Comp. Ctr., Ltd.)

#### Research Part-time Worker

Kazuhito ITO

**Administrative Part-time Worker**

Kanako FUJITA

**Assistant**

Asako SAKIHAMA

**List of Publications & Presentations****Publications****[Original Papers]**

- S. Katsuda, T. Enoto, A. N. Lommen, K. Mori, Y. Motizuki, M. Nakajima, N. C. Ruhl, K. Sato, G. Stober, M. S. Tashiro, Y. Terada, and K. S. Wood, "Long-term density trend in the mesosphere and lower thermosphere from occultations of the crab nebula with X-ray astronomy satellites," *J. Geophys. Res. Space Phys.* **128**, e2022JA030797 (2023).
- A. Miyazaki, M. Tsuge, H. Hidaka, Y. Nakai, and N. Watanabe, "Direct determination of the activation energy for diffusion of OH radicals on water ice," *Astrophys. J. Lett.* **940**, L2 (2022).
- Y. Miyake, N. Ikoma, K. Takahashi, Y. V. Sahoo, and H. Okuno, "Test of  $^{107}\text{Pd}$  transmutation with macroscopic quantities," *J. Nucl. Sci. Technol.* **59**, 1536 (2022).
- K. Takahashi, Y. V. Sahoo, Y. Nakai, H. Motoyama, and Y. Motizuki, "Annually resolved profiles of  $\delta^{34}\text{S}$  and sulfate in shallow ice core DF01 (Dome Fuji, Antarctica) spanning the nineteenth century and their geochemical implications," *J. Geophys. Res. Atmos.* **127**, e2021JD036137 (2022).

**Presentations****[International Conferences/Workshops]**

- Y. Motizuki (invited), "Verifying footprints of solar cycles and supernovae in polar ice cores," International Conference on Astrophysics with Radioactive Isotopes (AwRI), Budapest & Online, June 12–17, 2022.
- S. Katsuda (poster), T. Enoto, A. N. Lommen, K. Mori, Y. Motizuki, M. Nakajima, N. C. Ruhl, K. Sato, G. Stober, M. S. Tashiro, Y. Terada, and K. S. Wood, "Measuring vertical density profiles of Earth's upper atmosphere using X-ray astronomy satellites," AGU Fall Meeting 2022, Chicago & Online, December 12–16, 2022.
- Y. Motizuki (poster), Y. Nakai, K. Takahashi, T. Imamura, and H. Motoyama, "Eleven-year, 22-year and ~90-year solar cycles discovered in nitrate concentrations in a Dome Fuji (Antarctica) ice core," The 5th ISEE International Symposium: Toward the Future of Space-Earth Environmental Research, Nagoya & Online, November 15–17, 2022.

**[Domestic Conferences/Workshops]**

- 望月優子 (招待講演), 「地質学的試料に残った超新星の痕跡について」, 新学術領域「地下から解き明かす宇宙の歴史と物質の進化」主催第9回超新星ニュートリノ研究会, 九州大学・伊都キャンパス & オンライン, 2023年3月2–3日.
- 望月優子 (招待講演), 「南極アイスコアから探る太陽活動と気候変動〜太陽の鼓動—星と私たちの繋がりを通して」, お茶の水女子大学理学部主催第10回宇宙講演会, 東京, 2022年12月10日.
- 望月優子 (招待講演), 「南極の水からひもとく地球と宇宙の歴史」, 朝日カルチャーセンター新宿教室, オンライン, 2022年8月27日.
- 望月優子 (招待講演), 「Solar activity signatures embedded in ice cores」, 宇核連—RCNP研究会「宇宙核物理の展開」, 豊中 & オンライン, 2022年7月20–21日.
- 中井陽一, 渡部直樹, 柘植雅士, 副島浩一, 「極低温氷表面に存在する OH ラジカルの可視域光による光脱離」, 日本物理学会 2023年春季大会, オンライン, 2023年3月22–25日.
- 中井陽一, 「低エネルギーイオンと極低温氷表面との分子生成反応」, 学術変革領域次世代アストロケミストリー第3回領域全体集会, 東京, 2023年3月7–9日.
- 勝田哲, 榎戸輝揚, L. Andrea, 森浩二, 望月優子, 中島基樹, R. Nathaniel, 佐藤浩介, S. Gunter, 田代信, 寺田幸功, W. Kent, 「X線天文衛星を用いた地球超高層大気密度鉛直構造の測定〜長期トレンドの調査〜」, 地球電磁気・地球惑星圏学会 第152回総会及び講演会 (2022年秋学会), 相模原, 2022年11月3–7日.

**Press Releases**

- 勝田哲, 榎戸輝揚, L. Andrea, 森浩二, 望月優子, 中島基樹, R. Nathaniel, 佐藤浩介, S. Gunter, 田代信, 寺田幸功, W. Kent, 「地球温暖化に伴う超高層大気の収縮を X 線天文衛星で解明」, 2023年2月2日, [https://www.riken.jp/press/2023/20230222\\_2/](https://www.riken.jp/press/2023/20230222_2/).
- 宮崎彩音, 柘植雅士, 日高宏, 中井陽一, 渡部直樹, 「極低温氷表面での OH ラジカルの動きやすさを初めて測定—宇宙の水微粒子上で分子進化が活性化する温度が明らかに—」, 2022年11月24日, [https://www.riken.jp/press/2022/20221124\\_1/](https://www.riken.jp/press/2022/20221124_1/).