

Nuclear Science and Transmutation Research Division

Astro-Glaciology Research Group

1. Summary of Research Activities

Our Astro-Glaciology Research Group 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 highenergy 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;
- Relationships between climate change and volcanic activity, and climate change and solar activity as well;
- 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 evolution of molecules in space.
- The application of analytical methods for measuring isotopes in ice cores to archaeological artifacts;

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

Special Temporary Research Scientist

Kazuya TAKAHASHI

Senior Research Scientist

Yoichi NAKAI

Technical Staff I

Yu Vin SAHOO

Senior Visiting Scientists

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Visiting Scientists

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Yoshinori IIZUKA (Hokkaido Univ.)

Hisashi HAYAKAWA (Nagoya Univ.)

Naoyuki KURITA (Nagoya Univ.)

Akira HORI (Kitami Inst. of Tech.)

Hideki MADOKORO (Mitsubishi Heavy Industries, Ltd.)

Kazuho HORIUCHI (Hiroasaki Univ.)

Hideaki MOTOYAMA (Nat'l Inst. of Polar Res.)

Visiting Technicians

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

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

Assistant

Keiko SUZUKI

Part-time Workers

Satomi NEGISHI (Research Part-time Worker I)

Kanako FUJITA (Administrative Part-time Worker I)

List of Publications & Presentations

Publications

[Original Papers]

- S. Katsuda, H. Fujiwara, Y. Ishisaki, Y. Maeda, K. Mori, Y. Motizuki, K. Sato, M. S. Tashiro, and Y. Terada, “New measurement of the vertical atmospheric density profile from occultations of the crab nebula with X-Ray astronomy satellites Suzaku and Hitomi,” *J. Geophys. Res. (Space Physics)* **126**, (4) e28886, doi:10.1029/2020JA028886 (2021).
- E. Tsantini, T. Minami, M. A. C. Ontiveros, K. Takahashi, and J. C. Melgarejo, “Sulfur isotope analysis to examine the provenance of cinnabar used in wall paintings in the Roman domus Avinyó (Barcelona),” *Minerals* **11**, (1) 6 (2021).
- K. Kitajima, Y. Nakai, W. M. C. Sameera, M. Tsuge, A. Miyazaki, H. Hidaka, A. Kouchi, and N. Watanabe, “Delivery of electrons by proton-hole transfer in ice at 10 K: Role of surface OH radicals,” *J. Phys. Chem. Lett.* **12**, 704 (2021).
- A. Miyazaki, N. Watanabe, W. M. C. Sameera, Y. Nakai, M. Tsuge, T. Hama, H. Hidaka, and A. Kouchi, “Photostimulated desorption of OH radicals from amorphous solid water: Evidence for the interaction of visible light with an OH-ice complex,” *Phys. Rev. A* **102**, 052822 (2020).

[Books]

- 望月優子, 佐藤勝彦, 「シリーズ現代の天文学第1巻 人類の住む宇宙 第2版」(第2刷観測進展にあわせ改訂), pp. 99–144 (「第3章 元素の起源」) 岡村定矩他編, 日本評論社, 2020年4月.
- 望月優子, 佐藤勝彦, 「天文学辞典 (インターネット版)」, 「r 過程」(部分執筆), <https://astro-dic.jp/r-process/>, 日本天文学会, 2020年10月.
- 望月優子, 佐藤勝彦, 「天文学辞典 (インターネット版)」, 「s 過程」(部分執筆), <https://astro-dic.jp/s-process/>, 日本天文学会, 2020年10月.

[Proceedings]

- 南武志, 高橋和也, 「与呂木古墳から出土した頭蓋骨付着朱の硫黄同位体比分析」, 三木市文化研究資料第35集 「与呂木古墳・与呂木12号墳—与呂木青葉台団地造成に伴う発掘調査報告書」, 三木市教育委員会, 35–39 (2021).
- 高橋和也, 南武志, 藤田淳, 池田征弘, 「硫黄同位体比分析による兵庫県の遺跡出土朱の産地推定」, 兵庫県立考古博物館 研究紀要 **13**, 53–58 (2020).

Presentations

[International Conferences/Workshops]

- Y. Motizuki (e-poster), Y. Nakai, K. Takahashi, J. Hirose, Y. V. Sahoo, Y. Yano, M. Yumoto, M. Maruyama, M. Sakashita, K. Kase, and S. Wada, “A novel laser-melting ice-core sampler with high depth resolution and high throughput for discrete ice core analyses,” The 11th International Symposium on Polar Science, Online event, November 16–December 18, 2020.

[Domestic Conferences/Workshops]

- 中井陽一, 日高宏, 渡部直樹, 「低エネルギーイオンと低温氷表面との反応実験装置開発の現状 2」, 日本物理学会第76回年次大会, オンライン発表, 2021年3月12–15日.
- 北島謙生, 中井陽一, W. M. C. Sameera, 宮崎彩音, 柘植雅士, 日高宏, 香内晃, 渡部直樹, 「極低温アモルファス氷への紫外光・電子線同時照射による負の氷透過電流生成」, 原子衝突学会第45回年会, オンライン発表, 2020年12月8–10日.
- 高橋和也, 中井陽一, 本山秀明, 望月優子, 「高感度硫黄同位体比分析法を用いた南極ドームふじ基地氷床コアから得られた試料の分析」, 日本分析化学会第69回年会, オンライン開催, 2020年9月16–18日.
- 菅澤佳世, 三宅美沙, 多田悠馬, 堀内一穂, 大谷昂, 笹公和, 高橋努, 松村万寿美, 落合悠太, 高野健太, 望月優子, 高橋和也, 中井陽一, 本山秀明, 松崎浩之, 「約100年分のドームふじアイスコア中¹⁰Beと³⁶Clの高分解能測定によるBC5480年宇宙線イベントの調査」, 第81回応用物理学会秋季学術講演会, オンライン開催, 2020年9月8–11日.

Press Releases

- Kazuya Takahashi and Yuko Motizuki, “Sticky tape: A key ingredient for mapping artifact origins,” March 9, 2020. https://www.riken.jp/en/news_pubs/research_news/pr/2019/20191126_2/