

## Technology, Problems and Solutions for Drinking Alcohol in Space

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### Abstract

There are various history and examples of alcoholic beverages in space. For example, in the past, yeast strains and raw materials necessary for fermenting alcoholic beverages have been taken to space, brought back to Earth, and brewed into space liquor, such as space SHOCHU, and space beer. The wine itself was taken into space, allowed to brew for more than a year, and brought back to the auction where it was auctioned off for more than 100 million yen and became the talk of the town. These products have been developed mainly for drinking on Earth. In the future, as more and more people travel to space and stay in space for longer periods, the need for alcoholic beverages that can be drinkable in space will increase.

This paper will present the technologies, problems, and solutions needed to fulfill these needs.

**Keywords:** Space Travel, Alcohol, Space beer, ASTRAX,

### 1. Introduction

As of 2023, when space travel has been opened to the private sector, drinking alcohol in space is a dream of many people. As of 2023, drinking alcohol is officially prohibited on the International Space Station. However, gradually the private sector is developing drinking alcohol in space, and ASTRAX is developing its service in light of the growing need for a service that provides alcohol in space.



Fig.1. Various types of alcoholic beverages

There are many types of alcoholic beverages in the world, including beer, wine, whiskey, tequila, shochu, sake, vodka, and brandy, but this paper will focus on beer, which ASTRAX is developing for consumption in space.

### 2. When drinking beer on Earth

There are two ways to drink beer on earth: 1) directly from the bottle, 2) directly from the can, and 3) by pouring it into a beer mug. In Japan in particular, lager-type beers are preferred, and the optimal beer temperature is said to be 4~8 degrees Celsius. [92] Pour into a relatively heavy glass mug. The mug should also be chilled. And this is my preference, originally popularized by a Japanese beer company on its own, but I like my beer to be 7:3 liquid to foam, and the foam to be fine-grained.



Fig.2. Beer liquid to foam ratio is 7:3

### 3. Beer experiments in previous zero gravity flights

In the past, some organizations have experimented with drinking beer in a weightless state using a zero gravity airplane.

In 2007, a popular Japanese TV personality tried to drink beer in a zero gravity condition in one such experiment. At that time, he opened a can of beer in zero gravity and was unable to drink or pour the beer because all the contents kept blowing out as foam. (b)



Fig.3. A zero gravity experiment with a popular Japanese celebrity drinking beer

In 2017, on the other hand, an Australian company, Vostok, developed a bottle that prevents all beer liquid from turning into foam, and experimented with drinking beer through a straw from that bottle, with success. (c)



Fig.4.Vostok's experiment with drinking beer in a zero gravity airplane

#### 4. Previous beer experiments in space

To date, there is no record of any experiments on drinking beer in space. However, as of 2023, the University of Colorado and Sapporo Breweries, Ltd. of Japan have conducted experiments to bring yeast and barley, which are essential for beer production, into space to see how they behave differently on the ground and in space, and companies such as Budweiser are developing beer for drinking on Mars in preparation for migration to Mars. companies such as Budweiser are developing beers that can be consumed on Mars in preparation for the migration to Mars. (d)

#### 5. Problems with drinking beer in space

There are many problems with drinking beer in space, especially in zero gravity. As mentioned in section 2,

when you try to pour beer into a beer mug, as soon as you open the cork, all the contents start to bubble up like when you open the cork of a champagne bottle, and they will continue to bubble up until the contents are gone. When this happens, you cannot pour it into the mug as you would when it is on the ground. You need to think about how to separate the beer foam from the liquid and the tools to pour the beer. Also, even if you could pour beer into a mug, the surface tension of the mug would be so strong that the beer would not be able to travel down the sides of the mug and into your mouth when you tilt the mug.

Furthermore, there is currently no equipment to cool things like refrigerators in spacecraft. If you end up drinking beer that is warm and fresh, it will ruin the beer. We need to think about cooling and keeping beer cool in the future.

#### 6. What is being done in ASTRAX

ASTRAX is preparing a lot of things to bring a space beer that can be drunk in space to the world.

##### 6.1. Space Beer Label Prototype Development Work Description

We designed a special label to represent a beer bottle for space use and produced a label (prototype) to fit the size of the designated bottle. The following tasks were undertaken in the production process.

##### 6.1.1. Label Design and Planning

In creating the label, we held several meetings and coordinated via e-mail regarding the direction of the design in consultation with Space Wa-mama, Sakai Kawagishi Brewery (Yasui Shoten), which provides the contents, and ASTRAX. Based on the results of these discussions, a professional partner for label production was selected, and a label design and label creation policy were determined.



Fig.5. Space Beer Label Design Plan

### 6.1.2. Adjust material, size and colour

The surface of the label has a glossy finish with film. We also created the shape (10cm X 15cm) to fit the size of the specified bottle. The colour is a gradient finish with a deep blue colour.

### 6.1.3. Label Data Preparation

We asked our partner, ASTRAX MISSION SERVICE Hiroyuki Kusama, to create the label data.

### 6.1.4. Label Creation

We commissioned our business partner, S1 DIGITAL DESIGNS Seiichiro Okuma, to create the labels.

### 6.1.5. Finished product

ASTRAX performed a final check and confirmation of the completed labels (10 labels), affixed them to the designated bottles, and delivered them.



Fig.6. Photo of finished label prototype development

## 6.2. Space beer mug (glass) prototype development work description

We developed a prototype beer mug (glass) for drinking beer in space. The development was based on the technology of beverages (space food) for astronauts to drink on the International Space Station (shape that takes into account surface tension and capillary flow, etc.), and the development of cocktail glasses for space use that ASTRAX had previously tested in prototypes and experiments (such as the demonstration of a cocktail glass for space use in a zero gravity flight). Based on our experience and technology, we finally developed and delivered two prototypes, one in the shape of a beer mug for drinking on the ground and the other in the shape of a glass used for drinking espresso in space. The following tasks were carried out for the prototypes.

### 6.2.1. Meeting with experts on space beer mug design

We had a meeting with Mr. Samuel M Coniglio, the representative of the ZERO GRAVITY COCKTAIL PROJECT, which is developing cocktail glasses for space use in the United States, and received advice on the shape of a beer mug (glass) for drinking beer in space. Based on the past experience of ASTRAX's zero gravity

flight in which the prototype of this space cocktail glass was tested in zero gravity, we received his advice on the prototype space beer mug to be used in this project.



Fig.7. ZERO GRAVITY COCKTAIL PROJECT logo



Fig.8. Experimentation of cocktail glasses for space use in a zero gravity airplane



Fig.9. Cocktail glasses for drinking in space

### 6.2.2. Design conception of space beer mug (glass)



In a zero gravity environment, the shape of a beer mug on the ground makes it impossible to drink well because the liquid clings to the mug wall due to surface tension. Therefore, it is necessary to create a shape that takes advantage of the capillary phenomenon (capillary flow). Therefore, based on the technology of beverages for astronauts to drink on the International Space Station (space food) (shapes that take into account surface tension and capillary flow) and our past experience and technology in developing cocktail glasses for space use (including demonstration tests of cocktail glasses for space use during zero gravity flights), we have created two types of drinking tools. One is a beer mug filled with a straw for drinking beer on the ground (using capillary action), and the other is a glass shape for drinking espresso in space (from the following reference information).



Fig.10. Coffee cups for drinking in space

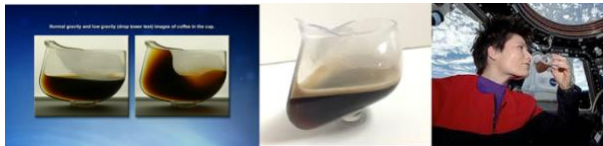


Fig.11. Drinking coffee in space using a space coffee cup

#### 6.2.3. Procurement of materials required for prototype space beer mug (glass)

We selected and procured the base mugs and glasses that could be deformed by heat for the space beer mug and space beer glass prototypes. In particular, since the degree of deformation differs depending on the material used for the heat deformable items, we procured items of various shapes and materials, conducted experiments on each, and selected the optimal base for the glasses.



Fig.12. Materials procured for the space beer mug prototype

#### 6.2.4. Prototype beer mug (glass) for drinking in space

The straw was filled to the brim in the shape of a beer mug, and adjustments were made through repeated experiments and verifications to ensure that the liquid could be sucked up by capillary action (and at the same time, to ensure that the liquid in the non-sucking area would come toward the mouthpiece), that the liquid could be easily poured, and that the shape of the mouthpiece made it easy to drink.



Fig.13. Prototype beer mugs for drinking in space



Fig.14. Prototype beer glasses for drinking in space

#### 6.2.5. Finished product

Prototypes of beer mugs and glasses for drinking beer in space (in zero gravity) were completed (two prototypes in total, one of each).

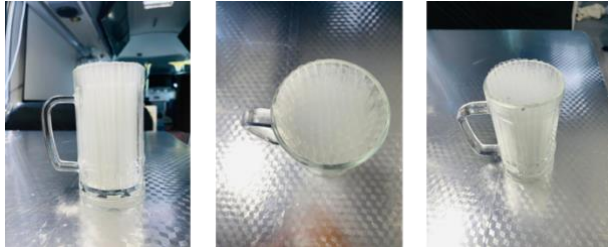


Fig.15. A completed prototype development of beer mug for drinking in space

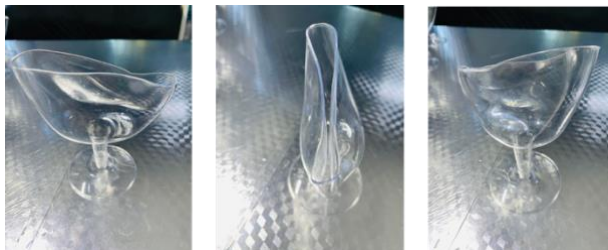


Fig.16. A completed prototype development of beer glass for drinking in space

## 7. Discussion and future

Space beer mugs are made by lining the inside of the mug with a straw-like substance. It is assumed that surface tension and capillary action (capillary flow) of the laid straw will make it easier for the beer to flow to the mouth part of the mug. If you are trying to drink in a place where there is gravity on the ground, you can drink with less force by sucking from directly above. This is a little different from the way we drink on the ground, where we tilt the beer mug and pour the beer into our mouths, but we think it is possible to drink beer with a closer appearance.

As for the glass, ASTRAX developed it on its own with reference to the cups used for drinking coffee in space. The glass is heat-processed to make it thinner overall and slightly wider around the mouth for a better feel around the mouth. As with the space beer mug, we believe that this also makes use of surface tension and capillary action (capillary flow) to suck beer from the mouth part of the drinking cup, allowing the beer to run down the side of the glass and be drunk. We will conduct verification experiments using this space beer mug and glass in a zero-gravity airplane in the future.

Although not a beer, French company Ummm is working with Axiom Space to develop a champagne that can be drunk in space. The champagne will be poured from a special bottle into a glass shaped like a shot glass.

The experiment will be tested during an Axiom Space spacecraft launch mission in the near future.

In the summer of 2023, an experiment was conducted in Japan using ASTRAX's zero gravity airplane service to drink tea from ordinary wine glasses on the ground. The tea poured into the wine glass became a large spherical mass of liquid and floated away in the weightlessness. The sphere of tea hit the experimenter's face and shattered in mid-air, making it difficult to put it in the mouth and drink it.

## 8. Conclusion

ASTRAX is developing space beer in response to requests to drink beer in space just as we drink it on the ground. The idea is to pour beer that has been chilled well into a mug or glass so that the ratio of beer liquid to foam is 7:3, and drink it from the mug or glass. By creating a concrete image in this way and making it possible to realize that image, we will create a service that will be necessary for many people to play an active role in space in the future.

Many steps still need to be taken before space beer can be drunk in space. ASTRAX will continue to develop space beer and contribute to the development of services that many people are demanding.

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## Technology, Problems and Solutions for Drinking Alcohol in Space 宇宙空間でお酒を飲む際に必要な技術と問題点および解決方法

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### アブストラクト

宇宙空間におけるお酒については、様々な歴史と実例があります。例えば、これまでの事例として、お酒を発酵させるために必要な酵母菌や原料を宇宙空間に持っていき、それを地上に持ち帰って醸造し、宇宙酒や宇宙焼酎、宇宙ビールとして販売されています。ワインそのものを宇宙空間に持っていき、1年以上醸造させて持ち帰り、オークションで1億円以上で競り落とされた話題になりました。これらは主に地上で飲むことを目的として開発されてきました。今後は宇宙旅行に行く人々が増え、宇宙空間での滞在が長期化すると、宇宙空間で飲めるお酒のニーズも増えてくるでしょう。本論文では、そのニーズに応えるために必要な技術や問題点、その解決方法について発表します。

**Keywords:** 宇宙旅行、アルコール(お酒)、宇宙ビール、ASTRAX、

### 1. イントロダクション

宇宙旅行が民間に開かれてきた 2023 年現在、宇宙でお酒を飲むことは、多くの人が夢見ることです。2023 年現在、国際宇宙ステーションではアルコールを飲むことを公式には禁止されています。ただ、徐々に民間では宇宙でアルコールを飲むことの開発が進められています。ASTRAX では、宇宙でアルコールを提供するサービスのニーズが高まっていることを鑑み、サービス開発を進めています。



図 1. さまざまな種類のお酒

なお、お酒の種類はビール、ワイン、ウイスキー、テキーラ、焼酎、日本酒、ウォッカ、ブランデーなど世界中に多く存在しますが、本論文では ASTRAX が宇宙で飲めるよう開発を進めているビールを中心に論じていきます。

### 2. 地上でビールを飲む時の様子

地球上でビールを飲む際は、①ボトルから直接飲む②缶から直接飲む③ジョッキについて飲む、という方法があります。特に日本では、ラガー系のビールが好まれていることもあり、ビールの適温が 4~8 度とされています。【92】ガラスの比較的ずっしりとしたジョッキに注ぎます。ジョッキも冷やしておきます。そして、これは私の好みで元は日本のビール会社が勝手に広めたものなのですが、ビールの液体と泡が 7:3 になるように、泡はキメが細かいものにしたいと考えています。



図 2. ビールの液体と泡は 7:3

### 3. 過去の無重力飛行でのビール実験

過去に Zero-G の無重力飛行機を使って無重力状態でビールを飲む実験を行った団体がいます。

2007 年に日本の人気タレントが、無重力状態でビールを飲むとした実験があります。その時は、無重力状態で



缶ビールを開けて、中身が全て泡となって吹き出し続けてしまったため、ビールを飲むことも注ぐこともできませんでした。【93】



図 3. 日本の人気タレントのビールを飲む無重力実験

一方 2017 年、オーストラリアの Vostok 社がビールの液体が全て泡にならないようなボトルを開発し、そのボトルからビールをストローで飲む実験を行い、成功しています。【94】



図 4. Vostok 社の無重力飛行機でのビールを飲む実験

#### 4. 過去の宇宙でのビール実験

これまでに宇宙空間でビールを飲む実験を行った記録はありません。ただ、2023 年現在までに、コロラド大学や日本のサッポロビール社が、ビールの製造に欠かせない酵母菌や大麦を宇宙に持っていき、それらが地上と宇宙空間とどう違う動きをするかを確認する実験をしていたり、火星移住に向けて、火星で飲めるビールの開発がパドワイザー社などの企業によって進められています。【101】

#### 5. 宇宙でビールを飲む際の問題点

宇宙、特に無重力状態の空間でビールを飲むには様々な問題があります。第 2 項で述べたとおり、ビールをジョッキに注ごうとした場合、栓を開けた途端にシャンパンの瓶の栓を開けた時のように中身が全て泡になって吹き出してきて、中身がなくなるまで吹き出し続けてしまいます。こうなると地上にいる時のようにジョッキに注ぐことはできません。ビールの泡と液体を分ける方法とビールを注ぐツールについて考える必要があります。また、ビールをジョ

ッキに注げたとしてもジョッキを傾けたところで、ジョッキの表面張力が強くてビールがジョッキの側面を伝って口に入ってくることはありません。

さらに、現在宇宙船の中に冷蔵庫のようなものを冷却する機材がありません。生温かいビールを飲むことになってしまえば、せっかくのビールが台無しです。今後、ビールの冷却・保冷についても考える必要があります。

#### 6. ASTRAX で実施していること

ASTRAX では、宇宙で飲める宇宙ビールを世に送り出すために、色々と準備をしています。

##### 6.1. 宇宙ビールのラベル試作開発作業内容

宇宙用のビールのボトルを表すために、専用のラベルをデザインし、指定されたボトルのサイズに合わせたラベルの制作（試作）を行いました。制作にあたって以下の作業を実施しました。

##### 6.1.1. ラベルのデザイン設計

ラベル制作にあたって、宇宙ワーママと中身を提供するさかい河岸ブルワリー（安井商店）と ASTRAX と協議の上、デザインの方向性について打ち合わせやメールでの調整を数回行いました。また、それらの協議結果に基づいて、ラベル制作に関わる専門パートナーを選定し、ラベルのデザイン及びラベル作成の方針を決定しました。



図 5. 宇宙ビールラベルデザイン案

##### 6.1.2. 素材、サイズ、色を調整

ラベルの表面はフィルム付きの光沢仕上げとしました。また、指定されたボトルのサイズに合わせた形状（10cm X 15cm）で制作しました。色はグラデーション仕上げとし、深みのある青色としました。

### 6.1.3. ラベルデータ作成

ラベルのデータ作成については、弊社パートナー事業者である ASTRAX MISSION SERVICE くさまひろゆき氏に依頼し、作成を行いました。

### 6.1.4. ラベル作成

ラベルの作成については、弊社パートナー事業者である S1 DIGITAL DESIGNS 大熊清一郎氏に依頼し、作成を行いました。

### 6.1.5. 納品

完成したラベル(10 枚)について、弊社にて最終チェックと確認作業を行い、指定されたボトルに貼った上で納品を行いました。



図 6. ラベル試作開発完成品写真

## 6.2. 宇宙ビールのジョッキ(グラス)試作開発作業内容

宇宙で飲めるビールのためのジョッキ(グラス)の試作開発を行いました。開発にあたっては、国際宇宙ステーション内で宇宙飛行士が飲む飲料(宇宙食)の技術(表面張力や毛細管現象(毛細管流)を考慮した形状など)、及び、過去に ASTRAX で試作・実験を行なった宇宙用カクテルグラスの開発(無重力飛行による宇宙用カクテルグラスの実証実験など)経験や技術を踏まえた上で、最終的に、地上で飲むビールのジョッキの形状のものと、宇宙用のエスプレッソを飲むためのグラスの形状を応用したものの 2 種類を試作し納品しました。試作にあたって、以下の作業を実施しました。

### 6.2.1. 有識者とのジョッキデザインについてミーティング

アメリカで宇宙用のカクテルグラス開発を行っている「ZERO GRAVITY COCKTAIL PROJECT」の代表の Samuel M Coniglio 氏とミーティングを行い、宇宙でビールを飲むためのジョッキ(グラス)の形状についてのアドバイスを受けました。過去に、ASTRAX が実施した無重力飛行で、この宇宙用カクテルグラスの試作品の無重力実験を行った経験も踏まえて、今回試作する宇宙用ビールジョッキについてアドバイスを受けました。



図 7. ZERO GRAVITY COCKTAIL PROJECT のロゴ

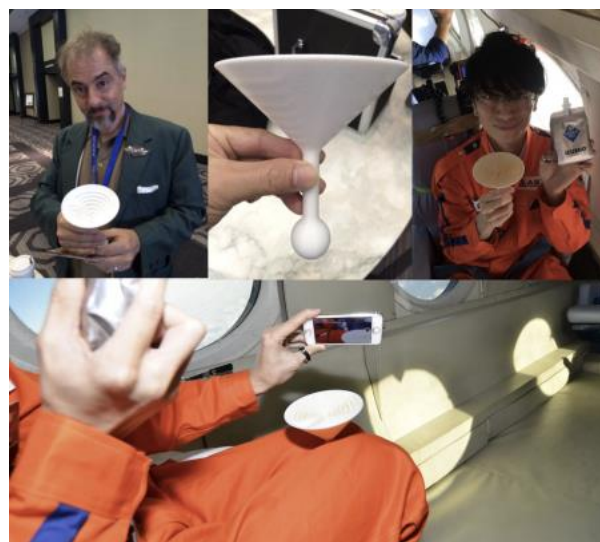


図 8. 無重力飛行機での宇宙用カクテルグラスの実験の様子



図 9. 宇宙用カクテルグラス

### 6.2.2. ジョッキ(グラス)のデザイン考案



無重力環境において、地上で飲むビールのジョッキの形状では表面張力によってジョッキの壁に液体がまとわりついてしまい、うまく飲むことができません。そこで、毛細管現象(毛細管流)を利用した形状にする必要があります。そこで、国際宇宙ステーション内で宇宙飛行士が飲む飲料(宇宙食)の技術(表面張力や毛細管現象(毛細管流)を考慮した形状など)と、過去に弊社で試作・実験を行なった宇宙用カクテルグラスの開発(無重力飛行による宇宙用カクテルグラスの実証実験など)経験や技術を踏まえた上で2種類の飲むためのツールを作成することにしました。地上で飲むビールのジョッキにストローをいっぱいに詰めたもの(毛細管現象を応用)と、宇宙用のエスプレッソを飲むためのグラスの形状(以下の参考情報より)を応用したものの2種類です。



図 10. 宇宙用コーヒーカップ



図 11. 宇宙で宇宙用コーヒーカップを使ってコーヒーを飲む様子

#### 6.2.3. ジョッキ(グラス)試作に必要な素材調達

ジョッキ(グラス)試作に必要なベースのジョッキやグラス(熱により形状を変形させられるもの)の選定及び調達を行いました。特に、熱によって変形させるものについては、材質が異なると変形の度合いが異なるため、さまざまな形状や材質のものを調達し、それぞれ実験を行い、最適なグラス(のベース)を選定しました。



図 12. 試作時に調達した素材

#### 6.2.4. 宇宙で飲めるビール用ジョッキ(グラス)の試作

ジョッキ型のものにストローをいっぱい詰めて、毛細管現象により液体が吸い上げられるか(同時に、吸っていない場所にある液体がちゃんと吸い口の方に寄ってくるか)、液体の注入がしやすいか、飲みやすい飲み口の形状などについて、何度も実験と検証を行いながら調整を行いました。



図 13. 宇宙で飲めるビール用ジョッキ試作品



図 14. 宇宙で飲めるビール用グラス試作品

#### 6.2.5. 納品

宇宙で(無重力状態で)ビールを飲むためのジョッキ及びグラスの試作品(それぞれ1個ずつ合計2個)を納品しました。

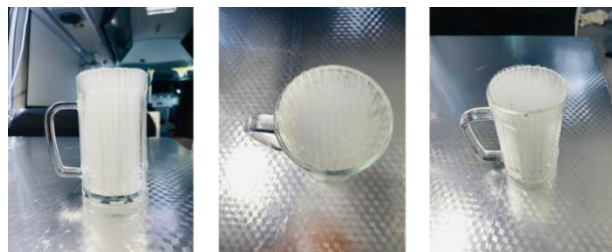


図 15. 宇宙で飲めるビール用ジョッキ試作開発完成品

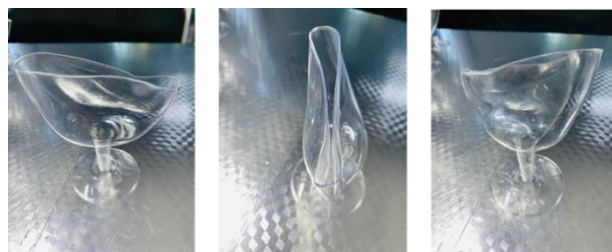


図 16. 宇宙で飲めるビール用グラス試作開発完成品

## 7. 考察と今後

宇宙ビール用のジョッキとグラスの開発。ジョッキの中にストロー状のものを敷き詰めたものです。これは、敷き詰められたストローの表面張力や毛細管現象(毛細管流)が起こり、ビールがジョッキの口部分に流れてきやすくなると想定しています。地上の重力がある場所で飲もうとした場合、真上から吸うことで少ない力で飲むことができます。ジョッキを傾けて口の中にビールを流し込む、という地上の飲み方とは少し違いますが、ビールを飲む際の見た目を近づけて飲むことは可能なのではないかと考えています。

グラスについては、宇宙でコーヒーを飲むためのカップを参考に、ASTRAX が独自で開発しました。グラスを熱加工で認め、全体的に厚みが薄い形状にし、飲み口のあたりを少し広げて口のあたりが良いようにしています。これも宇宙ビール用のジョッキと同様、表面張力や毛細管現象(毛細管流)を利用して、飲み口の部分からビールを吸うことで、グラスの側面を伝ってビールを飲むことができると考えています。今後この宇宙ビール用のジョッキとグラスの無重力飛行機を使った検証実験を行っていきます。

なお、ビールではないですが、フランスの Ummm 社は Axiom Space 社と共同で、宇宙で飲めるのシャンパン開発を行っています。特殊なボトルからショットグラスのような形状のグラスに注いで飲むというものです。近年中に行われる Axiom Space 社の宇宙船打ち上げミッションで実験が行われることでしょう。

一方 2023 年夏に、ASTRAX の無重力飛行機を使ったサービスを利用して、日本で地上にある普通のワイングラスを使って飲み物(紅茶)を飲む実験が行われました。ワイングラスに並々と注がれた紅茶は、無重力状態になった瞬間大きな液体の球体の塊となり、浮いてしまいました。そのまま実験者の顔面に当たり、紅茶の球体が空中で砕け散ってしまい、口に入れて飲むことは難しい状態でした。

## 8. 結論

ASTRAX では、ビールを地上で飲むのと同様に宇宙で飲みたい、という要望を受け、宇宙ビールの開発を進めています。どんなことかという、しっかり冷やしたビールを、ビールの液体と泡が 7:3 になるようにジョッキやグラスに注いでジョッキやグラスの飲み口から飲む、というものです。そうやって具体的にイメージをして、そのイメージを実現できるようにしていくことによって、今後宇宙で多くの人々が活躍していく上で必要なサービスが出来上がっていくことになります。

宇宙ビールを宇宙で飲めるようになるまで、まだ多くの段階を踏む必要があります。今回はその開発の経過を発表しました。ASTRAX では引き続き宇宙ビールの開発を進め、多くの人々が求めているサービス開発に貢献していきます。

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