# ABSTRACT

The Fourth International Symposium on Solar Sailing 2017  
17th - 20th January, 2017, Kyoto, JAPAN

## Title of Paper
Deployable Parabolic Sail Structure for Solar Photon Thrusters

## Corresponding Author
<table>
<thead>
<tr>
<th>Name</th>
<th>Geoffrey Knott</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Mr.</td>
</tr>
</tbody>
</table>
| Affiliation   | Dept. of Mechanical Engineering & Surrey Space Centre  
                University of Surrey, Guildford, UK |

## Co-Authors
<table>
<thead>
<tr>
<th>Name</th>
<th>Agnieszka Suliga</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Ms.</td>
</tr>
</tbody>
</table>
| Affiliation  | Dept. of Mechanical Engineering & Surrey Space Centre  
                University of Surrey, Guildford, UK |

<table>
<thead>
<tr>
<th>Name</th>
<th>Andrew Viquerat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title</td>
<td>Dr.</td>
</tr>
</tbody>
</table>
| Affiliation  | Dept. of Mechanical Engineering & Surrey Space Centre  
                University of Surrey, Guildford, UK |
Deployable Parabolic Sail Structure for Solar Photon Thrusters

Geoffrey Knott\(^a\) Agnieszka Suliga\(^b\) Andrew Viquerat\(^c\)

Dept. of Mechanical Engineering & Surrey Space Centre
University of Surrey, Guildford, UK

* Corresponding author \(a\) PhD Student | g.knott@surrey.ac.uk | (+44)7932 734 189  
\(b\) PhD Student | a.suliga@surrey.ac.uk  
\(c\) Lecturer | a.viquerat@surrey.ac.uk

The architecture for a deployable parabolic sail structure for solar photon thrusters (SPTs) [Forward, 1990] is presented. SPTs decouple the functions of collection and reflection of light and many advantages over flat solar sails (FFSs) [Flint, 2004] including; constant effective area i.e. always Sun facing, higher thrust performance over all coning angles, lower attitude control system requirements, enabling larger payloads, reduced sail collector size and possible combination of propulsion, power generation and high gain antenna functions.

Although recent and increasingly realistic studies [Dachwald, 2011; Fieseler, 2015] have concluded SPTs are currently an unattractive option, the motivation behind this work is to progress the novel SPT concept by resolving one of the problems identified; presenting a feasible solution for deployment and maintaining tight control over the collector shape.

The sail design envisaged is comprised of several laterally curved, bistable composite slit tubes – a prototype is shown in Figure 1. These provide the deployment method and support structure for a suitably thin, lightweight and reflective material as illustrated in Figure 2. This study focusses on the curved slit tube support structure. Selecting carbon-fibre/epoxy composite materials over metal ones e.g. copper-beryllium enables mass savings and the manufacture of bistable-over-the-whole-length tubes, which result in controlled and compact deployment.

The vibration characteristics of the support structure are also investigated experimentally to conclude the reliability of the focal point. The collector material should be attached to the laterally curved tubes such that it is kept in tension to ensure the smoothest possible surface.

The composite slit tube surfaces are modified with silicon nanoparticles to significantly enhance space durability. The effects of the harsh space environment of 400km and upwards on the sail structure are considered given the long duration that solar sail missions are designed to undertake, and the susceptibility of purely organic materials to degrade by ultraviolet radiation, atomic oxygen and high vacuum.
The Fourth International Symposium on Solar Sailing  
17-20th January 2017  
Kyoto Research Park, Kyoto, Japan  

Figure 1: A laterally curved, bistable composite slit tube glass fibre prototype  

Figure 2: The solar sail structure at; A) start of deployment, B) midway through deployment and C) fully deployed with parabolic solar sail (semi-transparent to show underlying support structure)  


