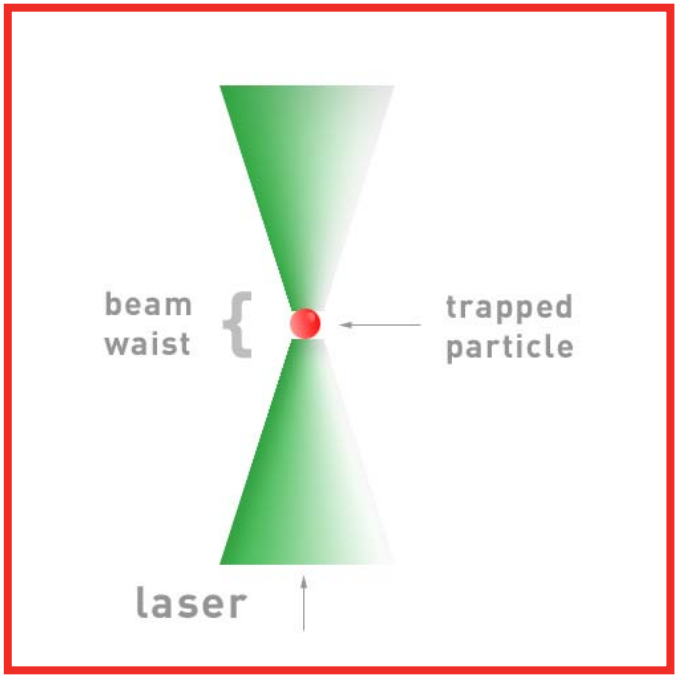
Case Study

World-First Alignment-Free Ti:S Laser Supports Technical Advances in Holographic Optical Tweezing at Glasgow University

Holographic Optical Tweezers

Optical Tweezers are a scientific instrument now routinely used in the physical manipulation of micrometer-scale objects such as individual cells, unicellular organisms such as bacteria and algae, and molecular-scale cellular components,inorganic particles and nanotools. Originally termed the single-beam gradient force trap, optical tweezers take advantage of the phenomenon whereby tiny particles can be trapped by the strong electric field gradient found at the focus of a laser beam (the "beam waist") created by sending the beam through a microscope objective. The first observation of optical scattering and gradient forces was made at Bell Labs in the early 1970's by Arthur Ashkin. Since then, the use of force microscopy has become a widely used tool in bioscience. During the 1980's the technique was used to trap and study the E-Coli virus and in the 1990's molecular scale biological motors, the engines of intracellular logistics. The same principle has been applied to the trapping of atoms (sub-nanometer scale) using resonant laser light and a magnetic gradient trap.



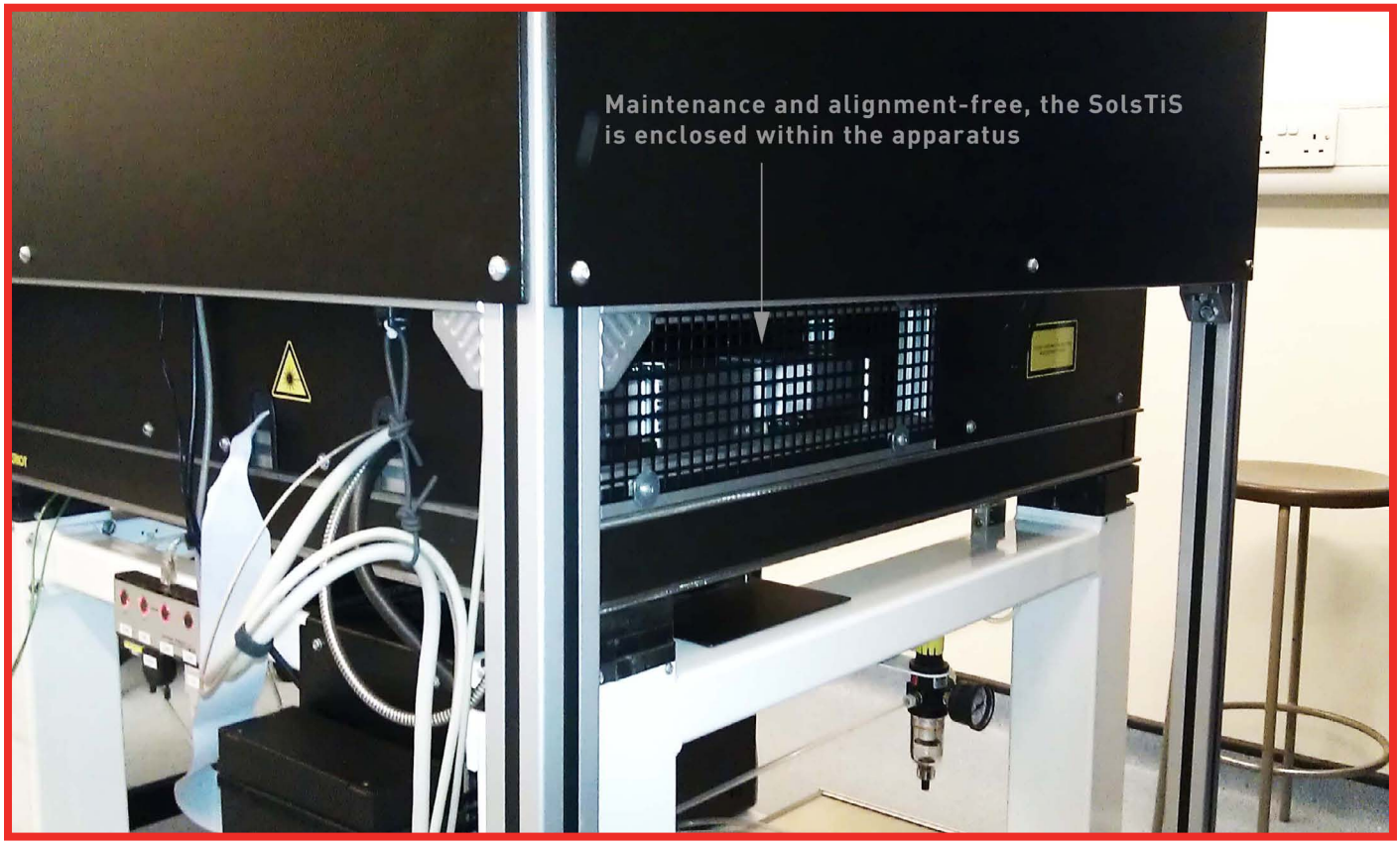
Two forces work on the microscopic dielectric particles trapped in the beam waist: their attraction down the gradient to the location of the strongest electric field and the buffeting they experience from the light itself in the direction of its path. The latter - scattering - force tends to push the trapped particle slightly downstream of the heart of the beam waist. Optical Tweezers therefore act like a spring which follows Hooke's Law, with the trapped particle held in a stable position close to the trap centre. (During a recent visit to the Optics Group at Glasgow University, we also saw how the trapped particles vibrated slightly as they were jostled by Brownian motion on the sample slide).

Glasgow University Optics Group

Our customer, the Optics Group in the School of Physics and Astronomy at Glasgow University, is a pioneer of optical tweezing technique and technology, including the use of haptic feedback in controllers and the recent development of an iPad-based controller - iTweezers - downloadable now from the App Store. Glasgow University Optics Group collaborates with non-specialist groups in institutions around the world who want to use the latest techniques in optical tweezing for their own research purposes but who do not themselves have expertise in the associated optical technology.

The first video below illustrates the iTweezers iPad application for controlling holographic optical tweezers developed by the GU Optics Group. In the second video, we see a 1-micron diameter glass bead being manipulated into a fissure in a microscopic fragment of chrome. When a haptic controller is used, the user experiences resistance at the point of insertion, as well as sensing the water in the sample "feeling like treacle."

The latest apparatus used by the GU Optics Group includes a SolsTiS CW Ti-S laser and an ICE controller, both of which are built into a set-up which also includes the microscope and server. This was a key requirement of the group, that the laser would not need to be extracted from the system for manual realignments, maintenance or adjustment. The main components in the holographic optical tweezers are the Group's proprietary controller, the microscope, the SLM which generates the hologram and makes it possible to generate multiple focal points in a single beam (and thereby multiple traps) the SolsTiS laser and the ICE controller. In the photograph below you can see the SolsTiS enclosed within the apparatus which also includes the microscope.



SolsTiS cw Ti:S Laser

The SolsTiS is the world's only alignment-free ultra-compact CW Ti:S laser. Tuning range and power settings are all adjusted remotely via Ethernet. <read more…> "This has been important to us," said Dr. Graham Gibson, a post-doc researcher in the group who demonstrated the system for us. "We haven't needed to touch the laser since it was installed into the system."

On the basis of its extreme reliability, usability and Ethernet Control, the SolsTiS is the tool of choice for researchers pushing at the frontiers of holographic optical tweezing.