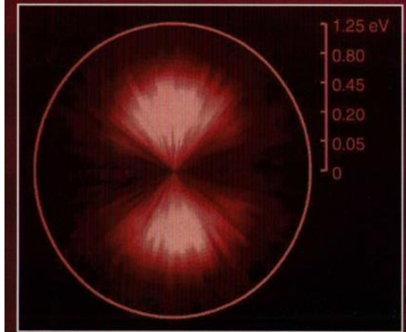
Terawatt Target Area

Target Area 1 provides a train of pulses at 10 Hz at the lower end of Astra's energy range. When compressed and focused these pulses reach intensities of 5×10^{16} W cm^{-2}, and are intense enough to break chemical bonds and ionise molecules.

Typical experiments in this area involve the study of photodynamics of atoms and molecules and non-linear optics. Previous experiments include the photoionisation of molecular ions, photodissociation of small molecules, laser desorption studies and femtosecond mass spectrometry of environmentally significant molecules.

TW Target Area Specifications

Wavelength	**800 nm**
Pulse duration	**50 fs**
Energy per pulse	**30 mJ**
Power	**0.6 TW**
Focused intensity	**5×10^{16} W cm^{-2}**
Repetition rate	**10 Hz**



Laser interaction with H_2^+ beam showing fragment yield at different polarizations

Multi-Terawatt Target Area

Multi-terawatt experiments are carried out in Target Area 2, which provides focused intensities up to 10^{19} W cm^{-2} on target in a custom-made vacuum interaction chamber. The pulse compressor is in a separate chamber, also under vacuum, as the intensity of the beam after compression is too great for it to propagate through air without severe non-linear optical distortion. This area is normally used for plasma physics experiments.

The experimental programme includes studies in high harmonic generation, pulse propagation and proton generation from laser irradiated targets.

Multi TW Target Area Specifications

Wavelength	**800 nm**
Pulse duration	**50 fs**
Energy per pulse	**300 mJ**
Power	**4 TW**
Focused intensity	**10^{19} W cm^{-2}**
Repetition rate	**2 Hz**

Thomson spectrometer trajectories of protons produced by laser interaction with mylar film

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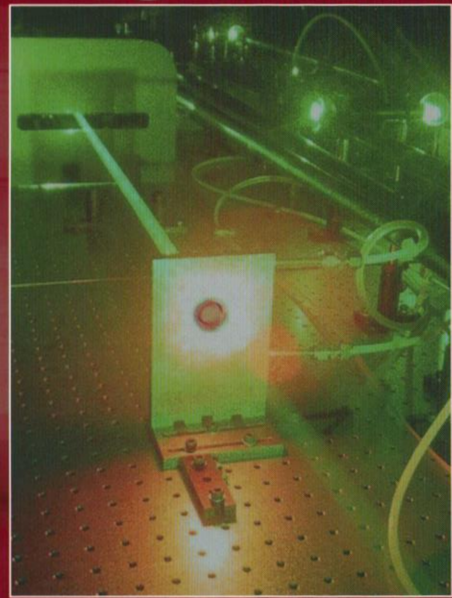

Central Laser Facility
Rutherford Appleton Laboratory

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THE ASTRA LASER

Astra is a high power, ultra-short pulse Titanium-sapphire laser facility. It provides pulses of 800 nm light with 50 fs duration at energies up to 300 mJ at 10 Hz repetition rate. With two experimental areas, and focused intensities up to 10^{19} W cm^{-2}, it offers new and exciting opportunities to researchers investigating the interaction of high-intensity laser light with matter.

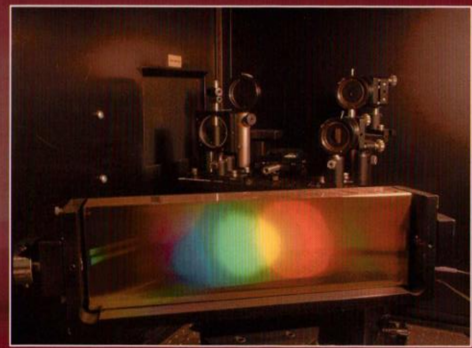
24 mm diameter Ti:Sapphire crystal

Astra generates high intensities by delivering moderate amounts of energy in a very short time. The laser crystals used in Astra are titanium-doped sapphire (TiS), which because of its large gain bandwidth is one of the best materials for generating and amplifying ultrashort laser pulses. The crystal shown here is the largest piece of TiS in the laser. Like other high powered lasers, Astra consists of an oscillator, producing pulses at low energy, and a chain of amplifiers. At the end of the chain the amplified pulses are delivered to two experimental areas.

The oscillator generates a train of high-quality pulses 13 ns apart, with a duration of 15 femtoseconds and an energy of 5 nJ. Non-linear optical effects make it impossible to amplify such short pulses directly to high energy, so a technique known as Chirped Pulse Amplification is used. The pulse is first stretched using two diffraction gratings, which delay the different wavelengths in the pulse by different amounts. The resulting pulses are 530 picoseconds long, and can be amplified successfully without non-linear distortion because their peak intensity is much lower.

Astra has three amplifiers, each of which consists of a TiS crystal pumped by powerful pulses of green light from another laser. The pump lasers deliver their pulses at 10 Hz, and are synchronised so the same pulse from the oscillator is amplified in all three amplifiers. The unamplified oscillator pulses are rejected using electro-optic gates. The panoramic picture below shows the first amplifier on the left, where the pulses pass ten times through a small TiS crystal, and are amplified to an energy of 2 mJ. In the second amplifier, on the right, the pulses pass through another crystal four times to boost their energy to 200 mJ, after which the beam is split into two. Half is sent to the terawatt experimental area, and half continues to the final four-pass amplifier, where the pulse energy is raised to around 1 Joule before the beam enters the multi-terawatt target area. The cover picture shows the final amplifier in operation.

At this stage the pulse duration is still 530 picoseconds. Before high-intensity experiments can be done the pulses must be recompressed. Each experimental area has a pulse compressor, such as the one shown below, in which another pair of diffraction gratings removes the delays that were introduced in the stretcher. The recompressed pulses typically have durations of 50 femtoseconds. Energies on target are 30 mJ in the terawatt area, and up to 300 mJ in the multi-terawatt area. Each area also has a pulse-selecting device, which allows experimenters to use either single pulses or pulse trains for their experiments.



Part of the TA1 pulse compressor

Panoramic view of the first two amplifiers. The region shown extends over 7 metres