Strontium Optical Lattice Clock

DATASHEET

Quantum Timing Metrology Navigation

OPTICAL FREQUENCY STANDARD

M SQUARED

Strontium Optical Lattice Clock

Our strontium lattice clock project aims to create the world's first commercially available fully integrated optical frequency atomic clock. The clock will be compact, transportable, easy to use and based on optical lattice technology enabled by the SolsTiS. The strontium lattice clock will achieve frequency uncertainties below 10^{-17} , a level unprecedented on the global market.

APPLICATIONS

- Remote Frequency Comparisons
- Time and Frequency Dissemination
- High Frequency Financial Trading
- Power Grid Management
- Global Navigation Satellite Systems (GNSS)
- Satellite-Free Navigation
- Relativistic Geodesy
- Time-Variation of Fundamental Constants
- Tests of General Relativity
- Gravitational Wave Detection

FEATURES

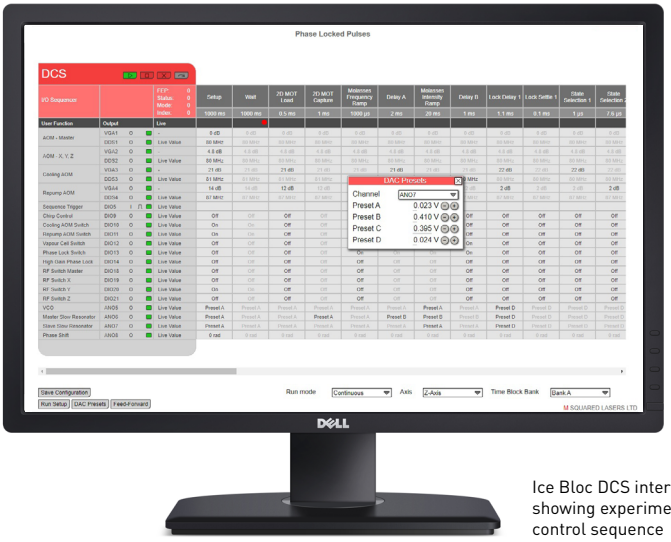
- Target frequency uncertainty < 10^{-17} level – more than 4 orders of magnitude better than the world's best commercial microwave clocks.
- Blue MOT atom number > 10^6
- A compact permanent magnet Zeeman slower.
- Designed to easily switch between cooling and trapping ^{88}Sr and ^{87}Sr.
- Sub-Hz linewidths via optical reference cavity lock.
- Fully customisable experiment timing and sequence control using the FPGA-based Ice Bloc DCS.

CORE COMPONENTS & MODULES

- 19" electronics rack for RF signal generation, laser stabilisation, and system control
- SolsTiS ECD-X at 461 nm for the blue cooling laser module
- Repump laser module at 679 nm and at 707 nm
- Red cooling and stirring laser module at 689 nm, including frequency shifting optics for switching between ^{88}Sr and ^{87}Sr
- SolsTiS at 813 nm for the optical lattice module
- Clock laser module at 698 nm
- Optical reference cavity module for clock laser stabilisation and frequency stability transfer to all other lasers
- Strontium vapour cell module for stabilisation to the atomic transition at 461 nm
- Atom chamber module for trapping and probing strontium atoms
- Ice Bloc DCS
- 2 x Ice Bloc LB-4
- 6 x Ice Bloc QCLD
- Ice Bloc DD-40 (used as strontium dispenser current supply)

SYSTEM CONTROL

- Easy-to-use control software provides complete control of optical system output
- Experimental sequence control via Ice Bloc DCS
- Ice Bloc DCS controls laser tuning, frequency generation, light switching, data collection triggers
- Lasers controlled with SolsTiS and Equinox user interfaces as well as Ice Bloc QCLD
- Remote control is also provided via TCP/IP commands



Ice Bloc DCS interface showing experiment control sequence

HOW IT WORKS

A neutral strontium optical lattice clock is based around an extremely narrow atomic transition in ^{87}Sr, with a frequency of around 429 THz and a linewidth of 1 mHz.

For clock operation, a sub-Hz linewidth clock laser at 698 nm is stabilised around this ultra-narrow transition.

Due to this narrow linewidth, clocks of this type have demonstrated systematic frequency uncertainties at the 10^{-18} level.

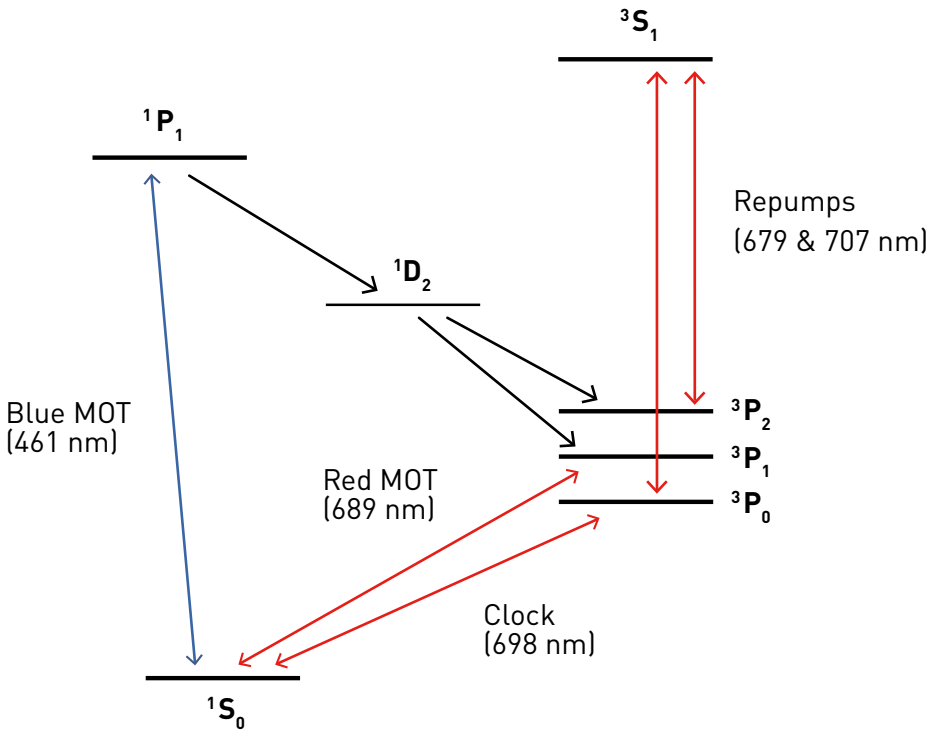
This makes strontium lattice clocks among the most accurate instruments in the world.

Before probing the strontium atoms with the clock laser, the atoms must first undergo a number of cooling and trapping steps.

The initial cooling stage (blue MOT) uses light at 461 nm to cool the atoms from 800 K down to a few milli-Kelvin.

At this stage, the atoms are still too hot to load into the optical lattice and additional cooling is required.

Simplified strontium energy level diagram showing the relevant energy levels for laser cooling and trapping. Included in the diagram are the blue MOT (461 nm), red MOT (689 nm), clock (698 nm) and repump (679 nm & 707 nm) transitions.



The second stage (red MOT) uses light at 689 nm to further cool atoms down to temperatures on the order of a micro-Kelvin.

Atoms in the red MOT are then transferred to an optical lattice formed using a SolsTiS tuned to 813 nm.

In the optical lattice, thousands of atoms are confined in a small area in the ground state and free from environmental influences.

The atoms are then ready to be probed with the clock laser.

As the clock laser must be stabilised to a sub-Hz linewidth, a high finesse optical reference cavity and low noise electronics must be used.

The clock laser frequency is centred around the absorption peak in the clock transition spectrum by monitoring the frequency where there is the highest probability of exciting the atoms.

The optical frequency of the clock laser can then be measured using an optical frequency comb.

SPECIFICATIONS

BLUE MOT SUBSYSTEMS	
ATOMIC SPECIES	Neutral ^{88}Sr or ^{87}Sr
ZEEMAN SLOWER ATOMIC BEAM LONGITUDINAL VELOCITIES	Final velocity of 50 m/s for initial longitudinal velocities 60 m/s to 240 m/s
MOT BEAM CONFIGURATION	Single beam
OUTPUT POWER 461 nm (BLUE MOT)	1.5 W
LINEWIDTH 461 nm	sub-MHz
OUTPUT POWER 679 nm (REPUMPER)	25 mW
LINEWIDTH 679 nm	sub-MHz
OUTPUT POWER 707 nm (REPUMPER)	25 mW
LINEWIDTH 707 nm	sub-MHz
ADDITIONAL SUBSYSTEMS	
OUTPUT POWER 689 nm (RED MOT)	25 mW
LINEWIDTH 689 nm	sub-kHz
OUTPUT POWER 813 nm (LATTICE LASER)	5 W
LINEWIDTH 813 nm	sub-kHz
ATOM NUMBER IN OPTICAL LATTICE	> 10^4
OUTPUT POWER 698 nm (CLOCK LASER)	25 mW
LINEWIDTH 698 nm	sub-Hz
CLOCK TYPE	Neutral ^{87}Sr optical lattice clock
TARGET FREQUENCY UNCERTAINTY	Below 10^{-17}

RELATED PRODUCTS

Quantum Computing Sensing Timing

ICE BLOC LB-4

A four-channel digital controller for stabilisation of lasers to external narrow-linewidth references operated via our simple to use Ice Bloc user interface.

CW Tunable NIR

SOLSTIS

The award-winning SolsTiS is a step-change in continuous-wave Ti:Sapphire laser technology. It's compact, ultra-narrow linewidth, fully automated, low noise and widely tunable.

CW

EQUINOX

Equinox is a single frequency, CW 532 nm laser source. It's inherently stable, low noise, narrow linewidth and like all M Squared products, it's compact, robust and fully-automated.

Quantum Computing Sensing Timing

ICE BLOC DCS

A highly versatile sequencing system with multiple high-speed digital I/O, analogue outputs and a four-channel digital synthesiser.

CONTACT

Whether you are looking for information or would like a question answered, reach out to us by phone or email.

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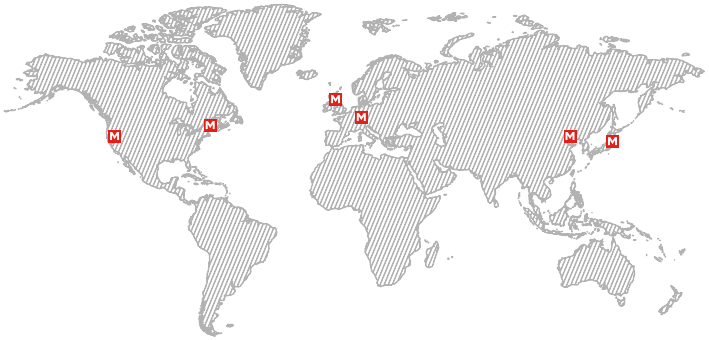

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