Item -1 Clock laser & Ultra-stable cavity system with accessories : A complete turn-key and standalone system for day-to-day operation with frequency stability better than 2×10^{-15} in 1 s at lab operating temperature of 22-25 C with stability ±1 C and usable clock lasers' line-width ~1 Hz.

Quantity - 01

1a. Ultra-stable Hz-laser system at fibre optic communication wavelength:

Specification of the Reference cavity:

(i) High finesse reference cavity of finesse ≥ 250,000 or better, FSR ≥1 GHz, Length of the cavity around 50-100 mm, ultra-low expansion material based spacer.
(ii) Active stabilization of temperature of the system within +/-10mK or better temperature sensitivity.
(iii) Active and/or passive vibration isolation system for cavity housing, acoustic and thermal isolation of the system.
(iv) The cavity housed inside of a vacuum vessel (vacuum level < $5x10^{-7}$ mbar) including complete vacuum system (viewports with AR-coated windows).
(v) Input and output coupling by PM SM fibres with FC/APC connectors, all optics for mode matching to the ultra-stable cavity, fibre collimator and optical isolator better than 40 dB,
(vi) All optical, mechanical, and electronic systems for Pound-Drever Hall locking, adequate systems for active power stabilization.
(vii) If required, detectors at the output coupling simultaneous use of CCD camera for mode detection and photo detector.

Specification of the 1550 nm laser:

(i) Central wavelength: approximately 1550 nm.
(ii) Allan deviation $2x10^{-15}$ or better at 1 s.
(iii) Free running linewidth should be 50 kHz or better.
(iv) Frequency stabilized output power should be around 10 mW.
(v) Frequency drift over 24 hours should be less than 20 kHz.

1b. Compact frequency doubled diode laser system: Fundamental at 934 nm (tunable to 321 060 748 386 320 ± 1 Hz) and frequency doubled at – 467 nm (tunable to 642 121 496 772 645 ± 1 Hz) (this is the Yb-ion E3 clock transition)

1) Fundamental laser at 934 nm: Output power – as required to get 700 mW @467 nm; free running linewidth of fundamental laser < 50 kHz; Mode hop free tuning better than 10 GHz; Coarse tuning ± 2 nm or better; At least two PM single mode fibre coupled outputs at 934 nm (for wavelength meter + coupling to cavity) and at 467 nm (for experiment); Fibre connectors FC/APC, fibre length 5 meter.
2) Frequency doubling: Integrated with resonant frequency doubling cavity in the laser system; double piezo lock and automatic relock including correct cavity mode selection in the laser system; Pound-Drever-Hall stabilization of doubling cavity with integrated EOM to separate internal and external stabilization schemes; free running linewidth at 467 nm < 100 kHz.
3) Automatic and software (SW)-triggered optimization of coupling into TA chip, into SHG, and into output fibers. Full hardware (HW) and SW integration of the amplified fundamental laser and frequency doubling unit. Full digital and remote control of the Compact frequency doubled diode laser system.
4) Drivers: Ultra-low noise current and temperature controller and digital stabilization system; Ultrafast (delay less than<15 ns) feedback electronics module for linewidth narrowing with PID for laser diode current and integrator for laser piezo
5) Miscellaneous (quoted price should include costs of the following items):

- All required electronics, racks, optical, mechanical and other components.
- A detailed performance report of the entire system before shipping of the item and after onsite installation.
- System integration that is transferring Hz laser stability and linewidth to the frequency- doubled diode laser system.

Accessories (bidder need to quote the following items together with their costs but IUCAA will have right to choose at the time of placing the order)

- Auto-realignment and optimization of the frequency doubled diode laser system.
- Two AOMs at 934 nm and 467 nm wavelengths (preferably fibre coupled AOMs, with single mode PM fibre with FC/APC) of carrier frequency in the range of 150-200 MHz each, connected to the fibre coupled outputs of 934 nm and 467 nm together with their drivers and RF amplifiers.
- Phase stabilization of optical fibres: Doppler cancellation/fibre noise cancellation system for long-distance transport of stabilized frequency doubled light at 467 nm wavelength at the end of > 5 m long fibre.
- Optical power meter with adequate thermal head (handheld complete system) for all wavelengths of interest and clock laser at different stages of the system in all power levels.
- Workstation Laptop for operation of the system (Intel Core i7; 16 GB RAM, 512 GB or above SSD, windows IOS, MS Office, 14 inch or above, 1 GB or higher graphics card)
- Extra set of connectors and cables those are specifically designed for this system

<u>Item 2. Femtosecond Optical frequency comb and accessories</u> : A complete turn-key system for day-to-day operation with frequency stability 10^{-16} or better in 1 s at lab operating temperature of 22-25 C with stability ±1 C and line-width ~1 Hz.

Quantity - 01

Specifications:

(i) Frequency stability 10^{-16} or better in 1 s.
(ii) Fundamental frequency comb central wavelength should be at 1550-1560 nm.
(iii) Wavelengths of interest 739 nm, 760 nm, 871 nm, 934 nm, 935 nm should be separated individually and ready to use.
(iv) Comb spacing approximately 200 MHz, Ultra-Low phase noise (< 100 mrad) frequency comb.
(v) Multiple output ports – 5 outputs at our wavelengths of interest and 2 outputs at the fundamental wavelength of the frequency comb.
(vi) Power at 2 output ports (at central wavelength of frequency comb) ≥ 7 mW.
(vii) Power of each 5 output ports at wavelength of interest should reach ≥ 50 nW/mode (or ≥ 0.3 mW/nm) with or without amplifier.
(viii) If required, Carrier Envelop Offset frequency measurement & stabilization/cancellation: f-2f comparison system using one of the output ports, essential and necessary electronics, optics and other necessary components for stabilizing offset of the frequency comb. Not applicable for frequency comb solutions with f_CEO (offset frequency) = 0.
(ix) Phase of the carrier wave in each pulse to be stabilized from pulse to pulse i.e. carrier envelop phase (CEP) stabilized outputs.
(x) Essential and necessary electronics, optics and other necessary components for stabilizing the repetition rate
(xi) Complete fiber coupled system: the output should have polarization maintaining (PM) fibre with FC/APC connectors couplers
(xii) Low noise beat node measurement systems for 934 nm and comb central wavelength including > 1 GHz optical filter; must provide an option to extend it to wavelengths of interest in future, locking electronics to transfer the stability of the ultra-stable cavity (as in Item 1) to frequency comb with fully automated controls.
(xiii) Essential optics along with low noise electronics for locking the comb output at 934 nm to an ultra-stable reference cavity
(xiv) If require, Automated cooling and heating system ($\pm 0.1^0$ C) for stable operation of frequency comb.
(xv) Miscellaneous (quoted price should include costs of the following items):
- A detailed performance report of the entire system before shipping of the item and after onsite installation.
- A short-term and long-term stability report of the system

Accessories (bidder need to quote the following items together with their costs but IUCAA will have right to choose at the time of placing the order)

- Single mode polarization maintaining optical fibres at the wavelengths of our interest and at the fundamental wavelength of the frequency comb (2 sets for each wavelengths), length 7 meter, FC/APC connectors on both ends.
- Low noise (phase noise level <= -170 dBc/Hz) pulse distribution distributer (at least 1 x 8 channels) @ 5 - 10 MHz with external referencing option
- Workstation Laptop for operation of the system (Intel Core i7; 16 GB RAM, 512 GB or above SSD, windows IOS, MS Office, 14 inch or above, 1 GB or higher graphics card)
- Low noise RF spectrum analyser (frequency range 1 Hz to 26 GHz; Phase noise @ 1 GHz 10 kHz offset ≤ -109 dBc/Hz, Displayed Average Noise Level < 100 dBm/Hz over the entire range; Bandwidth 25 MHz or better; Computer interfacing)
- Extra set of connectors and cables those are specifically designed for this system

General Instructions to the bidders for submitting their quotations for the Items 1 & 2:

1) The bidders should supply a "compliance report" for the items – 1 & 2 following the attached format.
2) We prefer both of the items 1 & 2 from a single manufacturer to ensure their compatibility & connectivity, provided they are L1.
3) In case products from the different suppliers are L1 for the Items – 1 & 2, system integration of the Items-1 & 2 have to be within the scope of the bidder.
   Here, the mentioned system integration includes, transferring stability of the "Ultra-stable Hz-laser system" to the optical frequency comb and synthesizing the clock laser's frequency using the stabilized optical frequency comb.
   Bidders are requested to quote charges for the system integration (if any) separately with their submitted quotations. Finally, IUCAA will have right to choose the system integration at the time of placing the purchase order.
4) Onsite installation and training of the systems need to be provided. If it is chargeable, bidders need to quote cost for the same. Finally, IUCAA will have right to choose the same at the time of placing the purchase order.
5) All systems to be operational using Indian power standard, or necessary adapters need to be supplied.
6) All software and manuals should be in English language only.
7) Bidder should quote the items with at least one-year warranty starting from date of satisfactory installation and acceptance of the system by IUCAA.
   Bidder should quote cost for extended warranty in year II, III and IV, finally, IUCAA will have right to choose the same at the time of placing the purchase order.
8) In case supplier have suppled similar items to anywhere else (India or abroad), bidder is requested to provide the order copy of the same.