Filling Technological Gaps for Planetary Science Missions with Customized SRI Solutions

Presented by Alex Hegedus (alex.hegedus@sri.com)

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Past Missions

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- Parker Solar Probe (**PSP**) – Wide-Field Imager for Solar Probe (WISPR)
  - Uses SRI's Active CMOS Detectors, Jim Janesick, jim.janesick@sri.com
- SRI CubeSat Imaging Radar for Earth Science (**SRI-CIRES**)
  - Mike Huff michael.huff@sri.com (ROSES 2016 NNH16ZDA001N-IIP)
  - Utilizes Interferometric Synthetic Aperture Radar (InSAR)
- Cyclone Global Navigation Satellite System (**CYGNSS**)
  - Data Analysis, April Warnock, April Warnock april.warnock@sri.com
- Sun Radio Interferometer Space Experiment (**SunRISE**)
  - Scientific Analysis Pipeline Design, Alex Hegedus alex.hegedus@sri.com *
- Radio Aurora Explorer (**RAX**) CubeSat
  - Scientific Payload Tony van Eyken anthony.vaneyken@sri.com (ATM-0121483)
- Farside Array for Radio Science Investigations of the Dark ages and Exoplanets (**FARSIDE**)
  - Scientific Analysis Pipeline Design, Alex Hegedus alex.hegedus@sri.com *
- Advanced Modular Incoherent Scatter Radar (**AMISR**)
  - Asti Bhatt asti.bhatt@sri.com and Tony van Eyken anthony.vaneyken@sri.com

* Work done while at University of Michigan

Areas of Expertise

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- **Incoherent Scatter Radars** – For NSF anthony.vaneyken@sri.com
- Interferometric Synthetic Aperture Radar – Used on CubeSat SRI-CIRES NASA Earth Science troy.stevens@sri.com
- Ground Penetrating Radar – For DoD/DARPA jeffrey.harrington@sri.com
- UHF Antenna Design Erin.rivard@sri.com
- Robotic Mobility jesse.wodin@sri.com
- Optics Design and Fabrication john.tower@sri.com brian.slovick@sri.com
- Novel diamagnetically levitated optical beam steering technology marcus.bagnell@sri.com
  - Highly stable, space rated lasers w/ micro-radians of precision shon.cook@sri.com
- **Quantum Sensors and Semiconductors** joseph.christesen@sri.com

Incoherent Scatter Radars

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- AMISR - Advanced Modular Incoherent Scatter Radar (sri.com)
- Studying upper atmospheric activity & space weather
- Modular design of AMISR enables relative ease of relocation
- Remote operation and electronic beam steering
- Multiple designs & locations of AMISR: PFISR, RISR-N, RISR-C
- SRI was responsible for lead design and construction of the facility and oversees operations and use during design verification tests.

From [6], layout of PFISR, the AMISR face at Poker Flat, Alaska

Quantum Receivers

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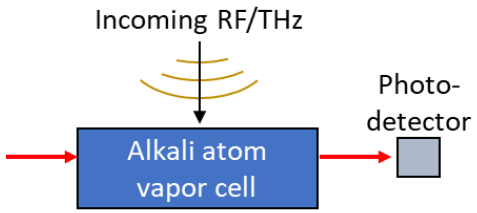
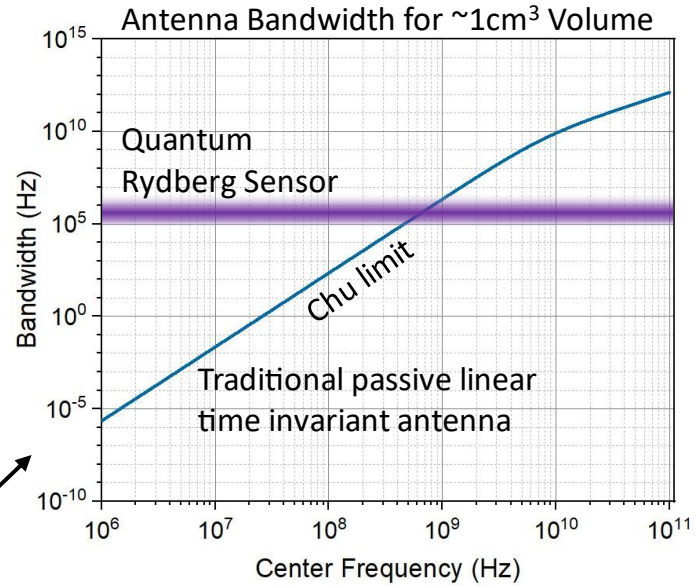
Approach: Use Rydberg atoms to convert RF to optical signals with high sensitivity. Each atom acts like an independent “antenna”, imprinting baseband of an incident RF carrier onto an optical signal.

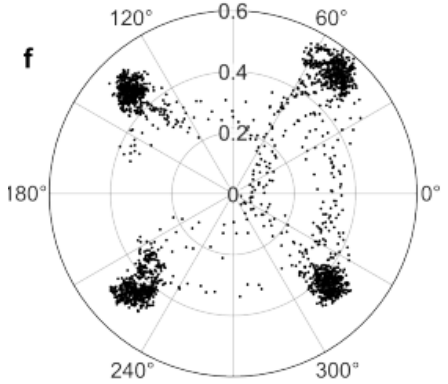


Basic quantum antenna schematic. Atoms in a vapor cell are prepared into Rydberg states. Incident RF modulates the probe laser light, encoding the RF signal onto an optical signal.



Advantages:

1. Resonant access to HF to sub-THz bands: SRI approach allows access to wide range of resonances, in some cases beating the Chu limit
2. All-dielectric construction/optical control and preparation: Unlike other quantum approaches, SRI has designed an all-optical preparation and control approach to minimize perturbations to nearby sources
3. Dynamic range: Receiver may be “turned off” via preparation lasers
4. Design with an eye toward manufacturing: Approach uses all-NIR lasers compatible with long fiber lengths and mature photonic integrated circuit (PIC) technology



Constellation diagram showing detection of a four phase-state signal using an *all-optical-capable* quantum interferometric Rydberg receiver

S. Berweger, A.B. Artusio-Glimpse, A.P. Rotunno, N. Prajapati, J.D. Christesen, **K.R. Moore**, M.T. Simons, C.L. Holloway, “Phase-Resolved Rydberg Atom Field Sensing using Quantum Interferometry”, arXiv:2212.00185, Dec. 1 2022

References & Acknowledgements

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