Sonification / Listening Up: Large Scale Sound Installation At MIT

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Haystack Seminar September 13, 2005

Outline

- Introduction
- Project genesis
- Sound construction details
- Final sound translation
- The installation: implementation and challenges
- Summary / invitation

HAYSTACK OBSERVATORY

MIT Millstone Hill Observatory

NSF

VISUAL ARTS PROGRAM

The Visual Arts Program focuses on the development of critical visionary strategies in artistic practice within the context of the advanced technological community of MIT... (view VAP Mission Statement)

Ion-acoustic waves

Naturally occuring plasma phenomena, especially in the ionosphere
One example of a plasma instability (free energy sink)

Simple model:

- 1-D, non-equilibrium
- Uniform, field-free plasma (no background E, B)
- Fluid approximation (e.g. magnetohydrodynamics – MHD)

Equations of state:

$$\rho_0 \frac{\partial V_1}{\partial t} = -\nabla p_1 \qquad \frac{\partial}{\partial t}\rho_1 = -\rho_0 \nabla \cdot V_1$$

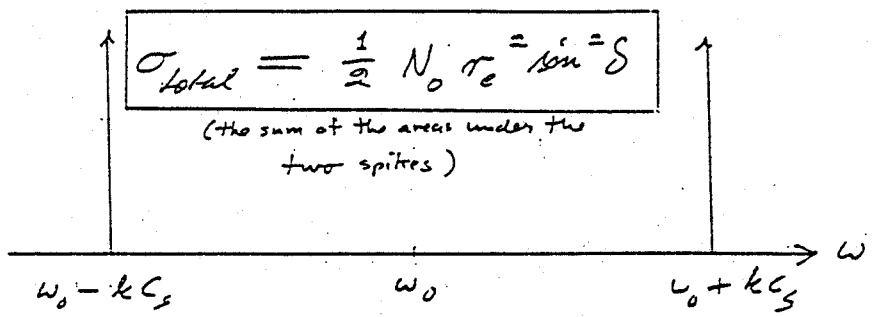
$$p_1 = p_0 \frac{\rho_1}{\rho_0}$$

Solution is compression (ion-acoustic) wave $\rho_1 = \hat{\rho_1} \sin(kx - \omega t)$

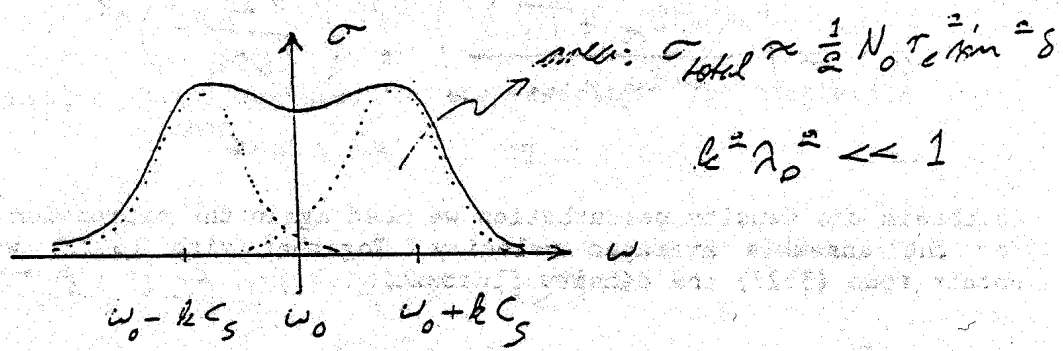
with ion sound speed

$$\frac{\omega}{k} = \sqrt{\kappa \frac{T_e + T_i}{m_i}}$$

Ion-acoustic spectrum in the ionosphere



Simple 1-D model result

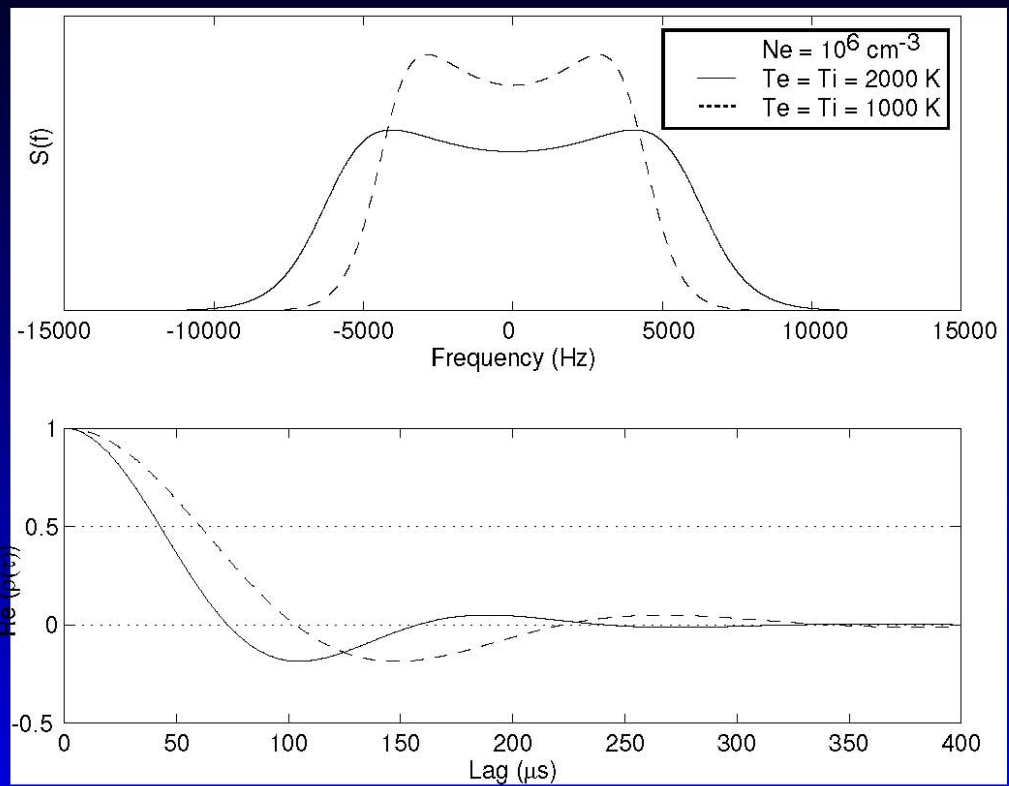


True situation:
with Landau damping

Incoherent Scatter Theory

Robust physical theory (1958-1962) predicts spectral variation with parameters

Thermal Inequality



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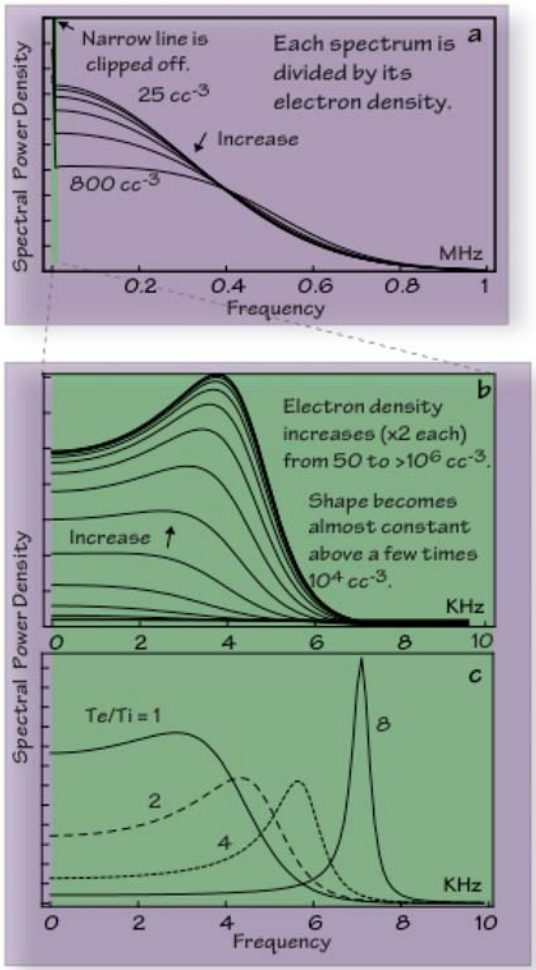
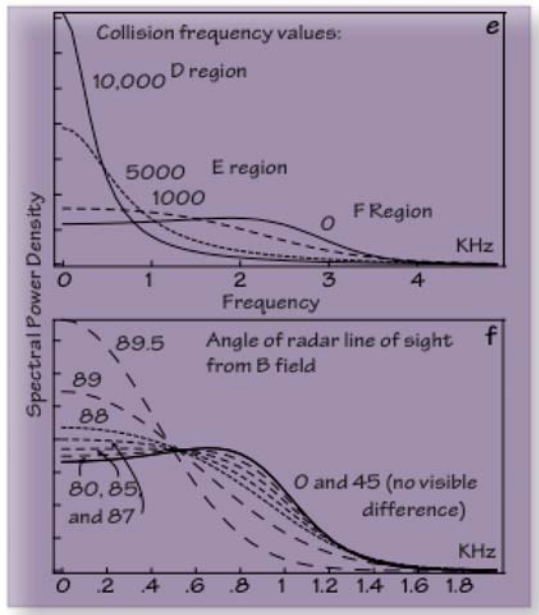


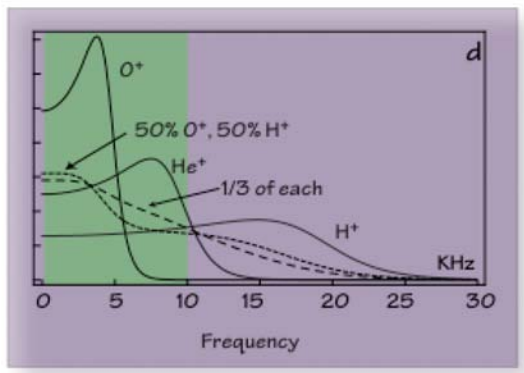
Part c shows what happens as T_e changes while T_i = 1000K and $n_e = 10^6$ cc^{-3}.

Parts e and f show the effects of the angle to the magnetic field and ion-neutral collisions.

Parts a and b show the ratios of the spectrum with the corresponding electron density. Part a shows that the wide Gaussian spectrum occurs only for very small electron densities. At higher densities which can be easily seen with a radar, the power shifts into a narrow line, resolved in (b).

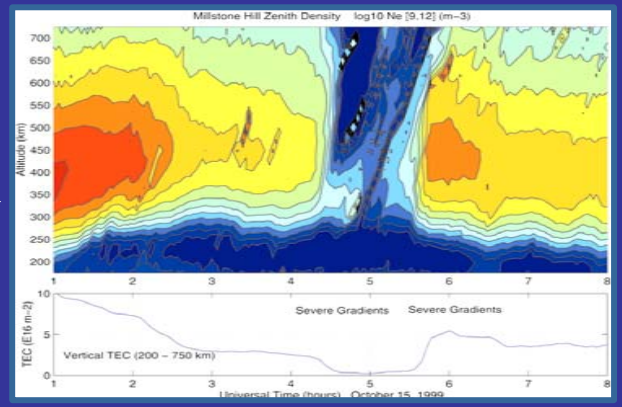
Part d shows the effects of various ratios of different ions with the other parameters as in part c with $T_e/T_i = 1$.





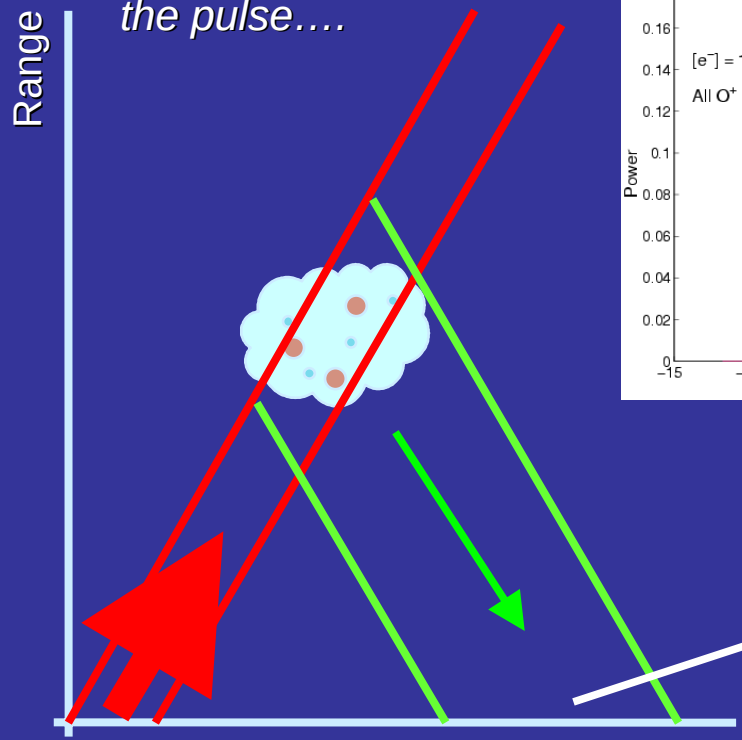
Observing the Ionosphere with Radar

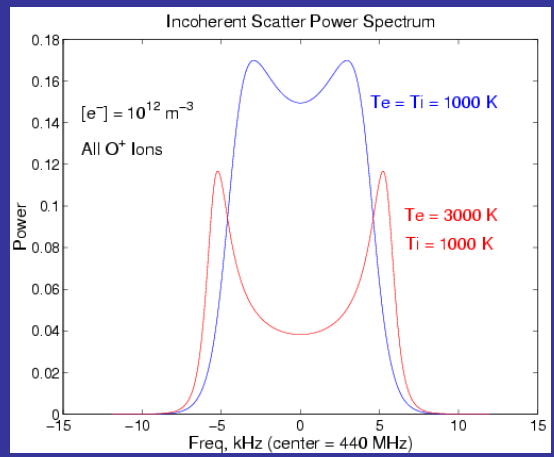
Iterative fitting reproduces the shape of the ionosphere



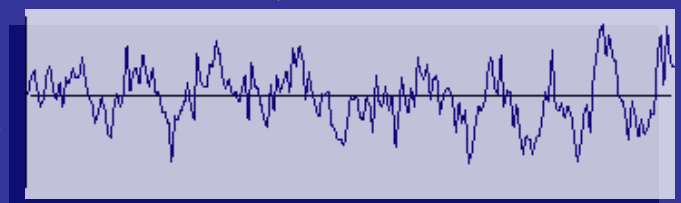
Incoherent Scatter

Electrons reflect the pulse….





Complex signal processing extracts the frequency spectrum



Noise like signal received

Only ~0.00000000000000001% of the transmitted power is returned!

High power pulse

Very sensitive receiver

Virtual Millstone Hill Radar

ISR-based
Ionospheric Models

Introduction
What's New
Virtual ISRs and Relatime Ionosphere
Real and Virtual ISR at MH
Viewing MH Historical Data

MH Electric Field Models
- 87 Version Run...
- 00 Version Output
- 04 Version

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EISCAT Svalbard Radar Models
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Midlatitude First-Principles Model
About ... Run ...

Related Papers

Comments? Contact S-R Zhang
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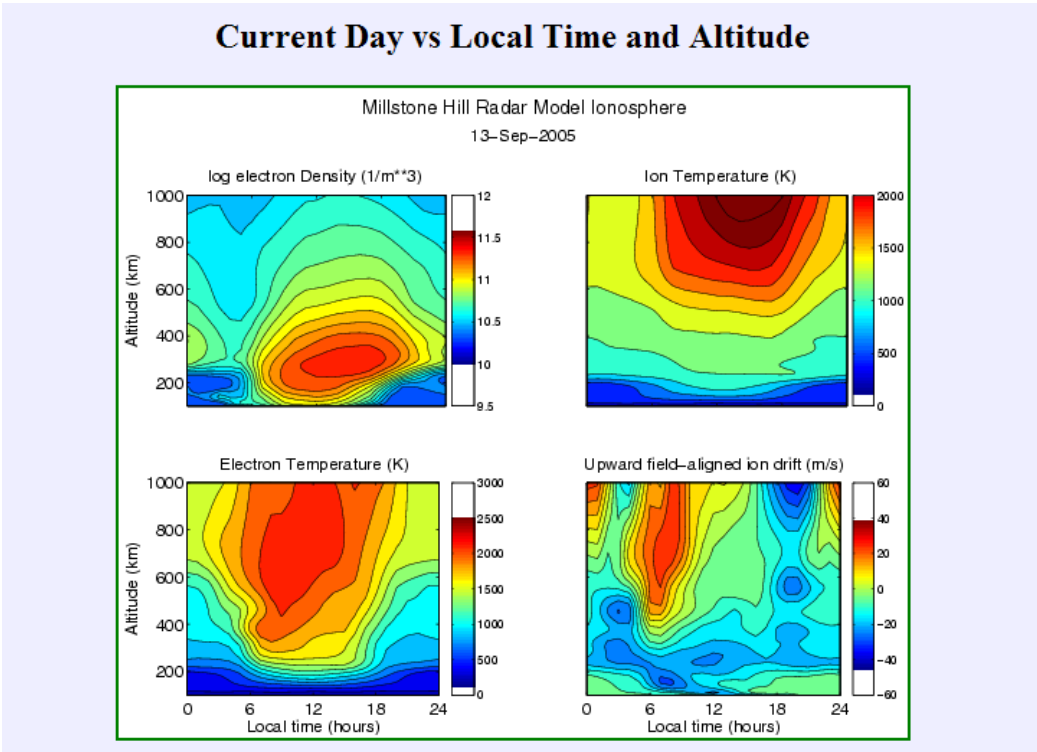
Updated Fri, 12 Aug 2005 00:04:17 GMT

Developed by S.-R. Zhang, J. Holt under NSF Space Weather grant
Based on 4 decade+ Millstone Hill incoherent scatter database
Provides empirical values of density, temperature, velocity



Ion-acoustic sound construction

Idea:

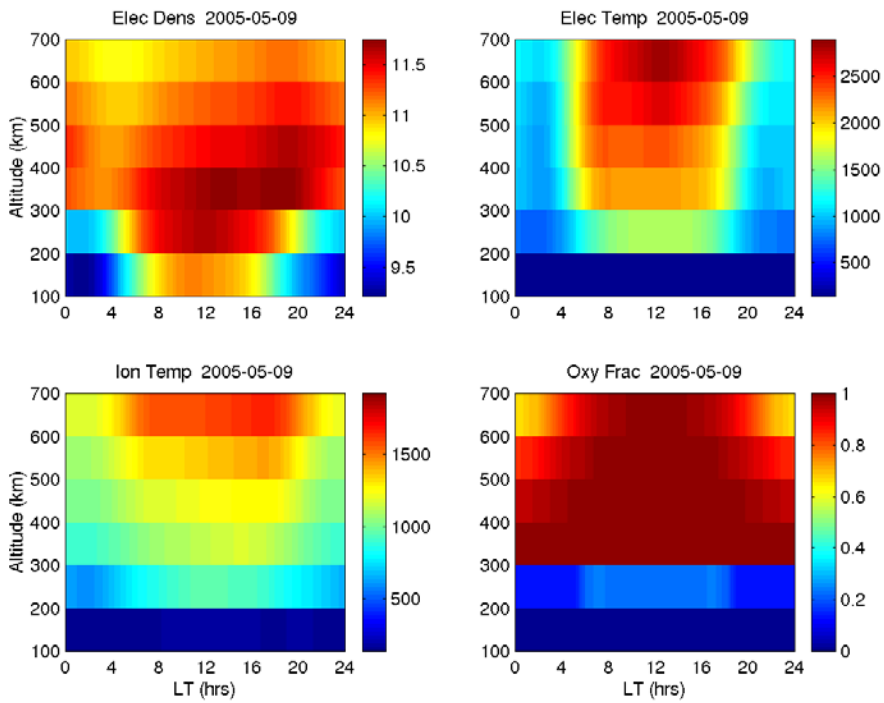
Drive IS theory calculation with Millstone Hill virtual radar model's physical parameters

Construct incoherent scatter ion-acoustic spectrum as function of altitude, time

Millstone Hill VMHR does not yet model composition – use International Reference Ionosphere IRI-95 model for ion composition

Assume geomagnetically quiet day: May 9, 2005

Allow parameters to change every 15 minutes over 24 hour period, and every 100 km over 100 – 700 km altitude



Ion-acoustic sound construction

Divide IS spectrum into 8 channels (2 kHz -> 16 kHz)

Output pure tone, scaled in amplitude, for each channel

8 freqs x 7 alts = 56 channels

Reduce to 35 channels (high freqs not present at lower altitudes)

Turn over results for further artistic adjustment