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ARTIFICIAL GENERATION OF ACOUSTIC AND GRAVITATIONAL WAVES IN THE ATMOSPHERE

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- SUMMARY AND CONCLUSIONS

OVERVIEW

- . Eastlund background is in plasma physics and commercial applications of microwave plasmas
- . This lecture reviews applications of microwaves to tornadogenesis mitigation and presents new concepts for electromagnetic wave interactions with the atmosphere that could be used for weather modification research.
- . Modification of steering winds by atmospheric heating
- . Modification of electrical charge distribution with plasmas
- . Artificial generation of acoustic and gravitational waves with heated plasma patterns in the atmosphere

NAS SEVERE WEATHER MITIGATION RESEARCH GUIDELINES

- . Theoretical modeling and simulation analysis of the physics, chemistry and biology of the relevant geophysical, geochemical climate and ecological systems
- . Study of potential for instability and chaos

- Small-scale mitigation experiments to determine physical, chemical and biological properties where they are known
- Detailed design, development and cost analysis of deployment systems
- Study of related natural events to understand their relevant properties including the statistics of their occurrence
- Study of possible ecological, geophysical, geochemical and atmospheric side effects, including consideration of reversability.

Severe Storm Energy Turnover

SMALL THUNDERSTORM

LARGE THUNDERSTORM

7×10^9 WATTS

7×10^{11} WATTS

7×10^{13} WATTS

7×10^{14} WATTS

MAJOR STORM SYSTEM

HURRICANE

Weather Modification Concepts

CONCEPT

- . Cloud Seeding
- . ARCO Patents
- . ESA Paper
- . Ross Hoffman (oil)
- . Moshe Alamaro(Jets)
- . HAARP

PURTURBATION

$< 10^{-5}$

- . 10^{-5} to 100
- . ~ 1 for 20 Minutes
- . $< 10^{-8}$
- . $< 10^{-8}$
- . $\sim 10^{-7}$

The ARCO Patents

- . Hired by ARCO in 1984 to find market for 23 trillion cubic feet of natural gas on North Slope

- . Developed three patents for ARCO issued to ARCO's subsidiary APTI for primarily military applications of a large phased array antenna located in Alaska and powered by natural gas generated electricity.
- . APTI has pursued many of these applications and with DOD sponsorship has built a large phased array antenna called the High-Frequency Active Auroral Research Project (HAARP) in Alaska
- . Power levels in the patents ranged from a few megawatts to 100 billion watts.
- . Weather modification was included as an application in the patents because the power levels were comparable to the energy flow in the jet stream and to the power of typical mesocyclones

Thunderstorm Solar Power Satellite

ARPS Code and Tornadogenesis

- . Advanced Regional Prediction System (ARPS) at Center for Analysis and Prediction of Storms

Center (CAPS) at University of Oklahoma

- . Includes conservation equations for momentum, heat (potential temperature), mass (pressure), water substance (water vapor, liquid and ice) subgrid scale turbulent kinetic energy and the equation of state of moist air.
- . Initial conditions include a clear day somewhere in the midwest, a cylindrical layer of air heated about 10 °K and wind shear structure as a function of altitude (obtained from balloons.)
- . The code predicts the development of a mesocyclone within 25 minutes.

ARPS MESOCYCLONE WITH TORNADO

ARPS CODE LIMITATIONS

- . MICROPHYSICS (RAIN DROP SIZE)
- . ABSENCE OF ACOUSTIC AND GRAVITATIONAL WAVE

PHENOMENA

MAY 27, 1977 DEL CITY BASELINE STORM

- . Heating Rate $.05 \text{ }^{\circ}\text{K/s-m}^3$, rain 2 g/Kg, Continuous
- . Heating Rate $.02 \text{ }^{\circ}\text{K/s-m}^3$, rain 2 g/Kg, At 1 Hour
- . Heating Rate $.04 \text{ }^{\circ}\text{K/s-m}^3$, rain 6 g/Kg, At 1 Hour

MICROWAVE ATTENUATION IN RAINFALL

ELIMINATION OF HOOK ECHO WITH MICROWAVE HEATING

KEY PARAMETERS OF MICROWAVE HEATING

- . Power levels required from microwave system were about 5×10^9 to 10^{12} watts
- . Volume of storm heated from 0.5 km^3 to 100 km^3
- . Code modification heated all regions of storm with rainfall above a specified amount. i.e. did not focus only on cold rainy downdraft

ARTIFICIAL PLASMA PATTERNS IN ATMOSPHERE

- . Artificial Ionospheric Mirrors (AIM) Air Force Program 1988-1993
- . Artificial Ionospheric Mirrors from Crossed Beams (Gurevich et al 1983 to 1997)

- . High Electric Fields Required for Breakdown of Ambient Atmosphere
- . Power levels required were above 10^9 watts and prohibitively expensive
- . Artificial Ionospheric mirrors have not been produced in the atmosphere

Field Pattern Generator

Field Pattern

Antenna

COSMIC PARTICLE IGNITION OF ARTIFICIAL IONIZED PLASMA PATTERNS

- . Eastlund filed a patent on Sept. 6, 2005
- . Cosmic particles can reduce the electrical breakdown field of the atmosphere by up to a factor of

- 40 and reduce the power required by a factor of 1600.
- . Artificial ionized plasma patterns can be created with megawatts of power using inexpensive magnetron power sources.

APPLICATIONS OF ARTIFICIALLY IONIZED PLASMA PATTERNS

- . Telecommunications
 - . mobile phones
 - . Long haul communication
- . Atmospheric Heating
 - . Controlled heating of specific atmospheric regions
 - . Controlling electrical conductivity of atmosphere
- . Weather Research
 - . Modification of steering winds

- . Modification of electrical patterns
- . Generation of acoustic and gravitational waves

PHYSICS OF COSMIC PARTICLE IGNITION

- . Cosmic Particles
- . Ionization Trails
- . Form Pattern and wait for particle
- . Detect particle and apply a pattern

EXPERIMENTAL EVIDENCE FOR COSMIC IGNITION BREAKDOWN

Microwave Lamp Ignition

Eastlund work leading to

U. S. Patents 5,038,664

Microwave Spark Chamber

(Kustom et al Nuclear Instruments

and Methods, Vol. 118,

pp. 203-211, 1974

Lightening Produced Sprites

(Gurevich et al, Physics

Today, May, 2005)

PLASMA PATTERN ATMOSPHERIC
HEATING

SIMULATION OF EARLY STAGE
PLASMA PATTERN

FULLY DEVELOPED PLASMA
PATTERN

PHYSICS OF HEATING PROCESS

WEATHER RESEARCH WITH
ATMOSPHERIC HEATERS

- . COSMIC PARTICLE IGNITED PLASMA
PATTERNS CAN BE FORMED FROM 10 KM TO
100 KM

- . PATTERN DIMENSIONS CAN BE FROM A FEW METER TO KILOMETER SIZES
- . COULD PROVIDE WEATHER RESEARCH WITH AN EXPERIMENTAL TOOL AS VALUABLE AS ACCELERATORS ARE TO PARTICLE PHYSICS

WEATHER RESEARCH APPLICATIONS

- . HEATING OF STEERING WINDS IN MESOCYCLONES AND HURRICANES
- . MODIFICATION OF ELECTRICAL PATTERNS IN MESOCYCLONES
- . GENERATION OF ACOUSTIC AND GRAVITATIONAL WAVES

PLASMA PATTERNS PROVIDING ELECTRIC CIRCUIT ELEMENT IN MESOCYCLONE

PLASMA PATTERNSM2400

PLASMA HEATER

THERMOSPHERIC GENERAL CIRCULATION MODEL FOR GRAVITY WAVE PROPAGATION

(Hocke and Schlegel, Ann. Geophysicae 14, 917-940, 1996)

GRAVITY WAVE MODES

GRAVITY WAVE ENERGY TRANSPORT

- . Vertical Flux of Energy Density Over Surface Corrugations From Wind Flow typically 1-2 watts/m² (Nappo, 2002)
- . Solar Irradiance about 1367 watts/m²
- . 10⁻¹ watts/m² out of troposphere (Hines, 1960)

- . 10^{-3} watts/m² above 80 KM
(Gossard, 1962)

GRAVITY WAVE AMPLIFICATION

- . Wave Amplitude of a Vertically Propagating Wave Can Increase with Altitude because air density decreases with height.

OBSERVATIONS OF GRAVITY WAVE WEATHER EFFECTS

- . Gravity Waves Propagating Across a stationary thunderstorm outflow associated with a jet streak in a boundary Produce Thunderstorms. (Koch and Dorian, Monthly Weather Review, Vol. 116, p2570, 1988)
- . Succession of Gravity Waves Produced Severe Weather in Oct. 22, 1996 Convection band. (McUllough, NWDO San Angelo, Texas, SR/SSD 97-20, May 1, 1997.)

- . The Unstable Cloud Layers in the Previous Figure Are Another Example of Gravity Waves Transferring Energy and Resulting in Unstable Behavior.

COMPARISON OF SOURCE FUNCTIONS OF NATURAL AND ARTIFICIALLY GENERATED GRAVITY WAVES

- . Vertical Energy Flux of Plasma Pattern Heaters Range from 50 to 500 watts/m²
- . Control of Heating Depth Can Directly Effect the Brunt-Vaisala Frequency. Where Γ = dry adiabatic laps rate in °K/m, and

HAARP and Generation of Gravity Waves

- . No Papers from the HAARP Research Have Directly Investigated the Generation of Gravitational Waves.
- . However, the Present Power Level of 3.6 Megawatts CW, the Antenna is Broadcasting at a vertical flux level of 2.1×10^{-3} watts/m² over a circle of radius about 30 km. This power level

is comparable with levels considered significant by Gossard, 1962.

- Sofko and Huang have measured Gravity Wave Generation from Joule Heating associated with solar flare events in the polar regions. (Sofko and Huang, Geophysical Research Letters 27, No. 4 pp 485-488 February 15, 2000)

QUESTIONS

- What Are Optimum Source Functions For Artificial Generation of Gravitational Waves?
- Can Acoustic Waves Be Useful In Weather Modification?
- Can Gravity Waves Produced By Joule Heating with HAARP Propagate Into Mid-Latitude Regions?
- Can Artificially Produce Gravity Waves Be Produced In Modes That Can Amplify?
 - By Matching Phase Velocity With Wind Velocity Such As In The Jet Stream?

SUMMARY

- New Methods of Heating Specific Regions of Atmosphere Proposed
 - Operational in All Weather (Unlike Lasers)

- Initial Experiments With Affordable Systems Possible.
- Artificial Generation of Acoustic and Gravitational Waves
- Weather Research
 - Heating Source Function Can be Applied in Specific Regions at any Altitude.
 - Incremental Changes in Air Flow Can be Safely Applied and Results Analyzed with Diagnostic Systems
 - Computer models Can be Developed and Results Verified.
 - The Technology of Artificial Ionospheric Heating Could be As Important for Weather Modification Research As Accelerators Have been for Particle Physics.
- Global Warming
 - Katrina Will Cost about \$300 Billion
 - It Is Time To Provide Funds for Application of the Scientific Method to Weather Modification and Control