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The Primary Purpose of the School or Why Are We Here?

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To Make it Possible the Continued Exploration of the Radio Universe,

Free of Interference

(as Much as Possible)

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Tools

- **Take stock of where we are (lay of the land):**
  - Telescopes
  - Basics of Radio
  - mm-λ Propagation
  - mm-λ Instrumentation
- **Allies: Remote sensing and space observations**
  - Remote sensing of the Earth
  - Active and passive sensing
  - Space Radio Obs
  - Active remote sensing from space
- **Isolation/Geographical Separation**
  - Quiet zones
  - Monitoring

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- Regulatory structures (at various levels)
  - National, Regional, International
  - Theory and Practice

"In theory, there is no difference between theory and practice. But, in practice, there is."

Jan L.A. van de Snepscheut

- Mitigation techniques
  - Software
  - Hardware
- Some current interference issues
  - Software defined and cognitive radio
  - Vehicular Radars
  - Iridium
  - White Spaces –608-614 MHz

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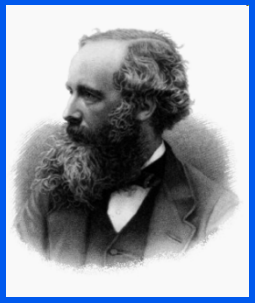
Birth

- 1865 Maxwell predicts the existence of electromagnetic waves



- 1886-87 Hertz demonstrates that the waves exist

- "This is just an experiment that proves Maestro Maxwell was right - we just have these mysterious electromagnetic waves that we cannot see with the naked eye. But they are there."

- "So, what's next?"

- "Nothing, I guess."

- 1890 Marconi invents the first practical wireless telegraph, develops commercial applications

  Bandwidth: unconfined Data Rate ~ 1 bit/s

  Limited number of telegraphs can operate simultaneously, as they interfere with each other!

- 1891 Heaviside

  "Three years ago, electromagnetic waves were nowhere. Shortly afterward, they were everywhere." (Electromagnetic theory, Vol. 1)

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Infancy

1900 First Radio stations:

- > US Navy among earliest to adopt radio technology (shore telegraph)

- **1906 Beginnings of regulation**
  - > 1906 Berlin Conference: INTERNATIONAL WIRELESS TELEGRAPH CONVENTION
  - > First "allocations" – to shipboard stations: λ = 300 m or 600 m

- **1910 Beginnings of broadcasting:**
  - > First AM stations; Lee De Forest invents the Audion tube

"De Forest has said in many newspapers and over his signature that it would be possible to transmit human voice across the Atlantic before many years. Based on these absurd and deliberately misleading statements, the misguided public ... has been persuaded to purchase stock in his company". US. Attorney General's accusation against De Forest, 1913

- **1912 Beginnings of Amateur radio**
  - > US Radio Act restricts amateurs to f > 1500 kHz, considered "useless"

- **1890s First attempts to detect radio emission from the Sun: Edison, Lodge, Wilsing and Scheiner**

- **1900 Nordman uses 175-m long antenna, at 3100 m height (Swiss Alps) in attempt to detect solar radio emission**

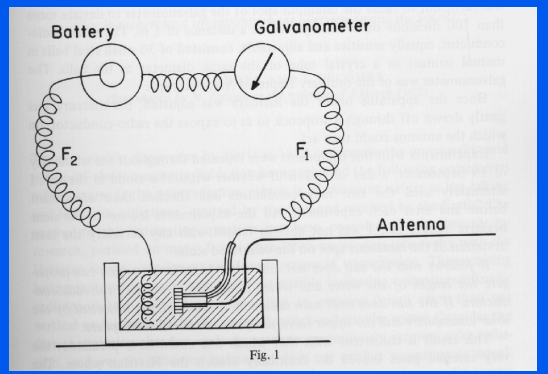

Fig. 1

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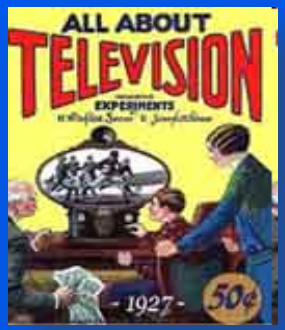
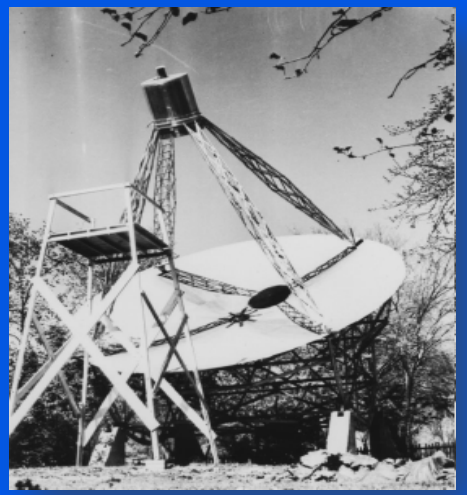
Adolescence

- 1914-1918 WWI: Beginnings of Aeronautical Radio
- 1925-1941 First TV transmissions (US, UK, Germany)
  - > "Television won't matter in your lifetime or mine" R. Lambert, The Listener, Editorial, 1936



- 1924-1944 Nyquist, Hartley, Shannon develop information theory

- 1932 Beginnings of Radio Astronomy
  - > K. Jansky, searching for the origins of interference in long distance telephone links, detects cosmic radio emission.
  - > Grote Reber builds first radio telescope specifically designed to detect cosmic emissions



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Youth

- 1920s – 1940 Development of radar: UK, Germany, France, U.S.
  - > First radars operate up to 30 MHz, later up to 3 GHz!
  - > Peak power ~ 200 kW

- 1950-60 FM radio and color TV become widespread

- 1947-1950 Radio astronomy develops, as surplus WWII military equipment (radar dishes) become available
- 1958 First radio map of the Galaxy, Oort, Kerr and Westerhout

- Earth rotation synthesis developed, pulsars discovered Nobel Prize to Hewish and Ryle, 1974
- 1959 Radio astronomy becomes a “radio service”
- 1963 IUCAF established

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The Satellite Era

- 1964 First communication satellite launched into geostationary orbit (1964)
  - considering f)
    "that while frequencies for communication with objects in extraterrestrial space are being selected at present on the basis of particular communication requirements and technological capabilities, the inevitable increase in this type of communication is likely to lead to a chaotic situation in the radio spectrum"
    from CCIR Recommendation No 259, Los Angeles, 1959
  - > 1960s and early 1970s – used for voice and limited data transmission
  - > 1975 First TV broadcasting satellites launched
- 1980s Low Earth Orbit (LEO) satellite systems developed
  - > GLONASS system developed; Experimental GPS satellites launched
  - > Satellite-based position determination becomes a major industry
  - > Multiple constellations developed for global or nearly-global voice and data coverage (Iridium, Globalstar, etc.)

1956 US National Radio Observatory (NRAO) established

1958 in the National Radio Quiet Zone (NRQZ)

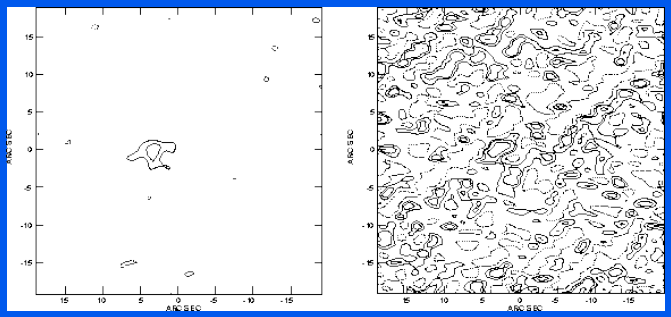
1980 VLA completed

Geographical Separation, Radio Quiet Zone No Longer Sufficient to Protect Radio Astronomers from Interference

1982 GPS, GLONASS, permanently block portions of the sky, from everywhere on Earth at all times in some bands

1993 VLBA completed

1998 Iridium system becomes operational



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Present

- 1970's Cordless phones
  - > At first, use ~2 MHz
  - > 1986 46/49 MHz bands available for cordless use
- 1990 900 MHz technology introduced – cordless phones become widespread
- 1974 Mobile phones introduced
- 2000 Wireless technologies become ubiquitous, local area networks (LANs) and countless other applications
- 2005 Emergence of software-defined and cognitive radio
- White spaces
- Dynamic spectrum selection

- 1993 Planning for SKA begins

Geographical Separation, Radio Quiet Zones and Regulatory Protections No Longer Sufficient
Mitigation Techniques Begin to Be developed

- 2011 First phase of eVLA project, completed
  - 1-50 GHz coverage
  - 8GHz bandwidth
  - World's most productive and versatile telescope at cm wavelengths
- 2012 SKA Site selection completed
- 2013 ALMA dedicated

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Final Topic

How Can We Ensure the Protection of Radio Astronomy in the Current Spectrum Environment?

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“To my knowledge, the IAU doesn't play an active role with ITU - and conversely, but perhaps I'm wrong. I know nothing about our membership with ITU, nor about the reasons why, while being a member, we currently don't have to pay the ITU fees.”