From Water Vapor on Venus to Neutron Stars in the Crab Nebula

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StaelinFest 2011
July 18, 2011

Figure 1

Dave Staelin
Radio Astronomy Pioneer

1963-1966	Venus and other planets (+1980s Jupiter) (Barrett)
1968*	CMB (Burke)
1968-1972	Pulsars (Reifenstein)
1979-1990	Optical interferometry (Shao)
1988*	Uranus (Eikenberry)

*minor but interesting activities

Figure 2

Venus Water Vapor Radiometer

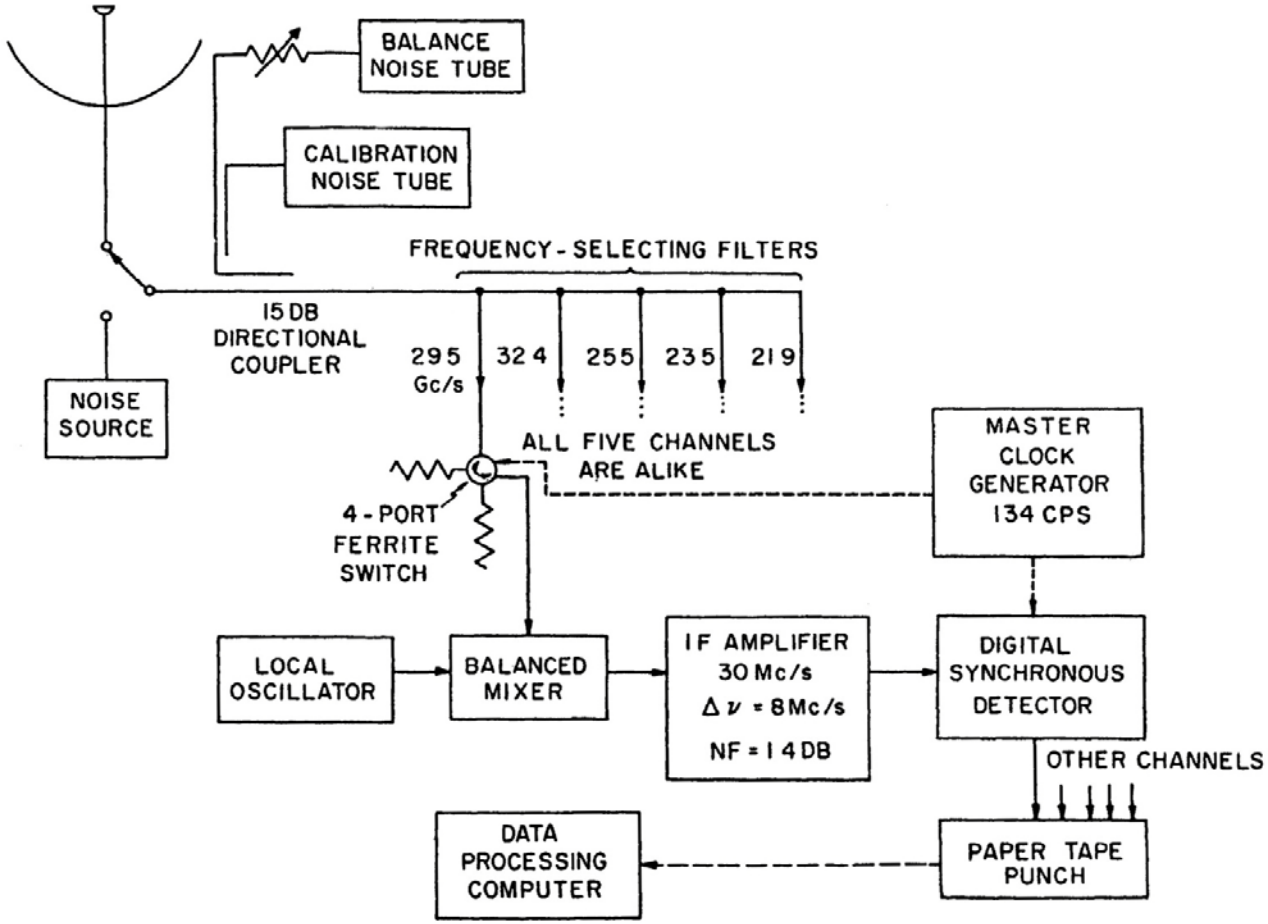


FIG. 2.—Block diagram of the 5-channel radiometer

Staelin and Barrett, ApJ, 144, 352 (1966)

Figure 3

Could Dave's instrument have detected water vapor masers?

(They were discovered by Townes in 1968 toward the Orion star-forming region.)

I. Sensitivity okay

ν = 22.235 GHz

$T_B \sim 10^{15}$ K

S up to 10^6 Jy (10^{-20} w m^{-2} hz^{-1})

$B \sim$ 100 KHz

Staelin's system

T_s = 22,000 K (ΔT = 4 K in 4 s)

B = 8 MHz

τ = 4 s

A = 30 m^2

$\Delta S = 2kT_s / A\sqrt{B\tau} = 360$ Jy

$S_{maser} = 10^6 (0.1/8) = 12{,}000$ Jy

SNR = 35 in 4 seconds

II. Where to point?

With a beam of 6' resolution, the sky has 4 x 10^6 pixels.

Figure 4

Technical Progress in Radio Astronomy at 22 GHz

	1964	2004	factor
D	8.5 m (28 ft.) (MIT LL)	100 m (GBT at NRAO)	14
T_s	22,000 K	22 K	10^{-3}

Ratio of sensitivities $\sim D^2/T_s$

$\sim 1.4 \times 10^5 = 2^{17}$ in 40 years

"Doubling time" (aka "Moore's law") = 2.3 years

Figure 5

Crab Nebula
(Supernovae of 1054 AD)
Scale 3’ or 2 parsecs

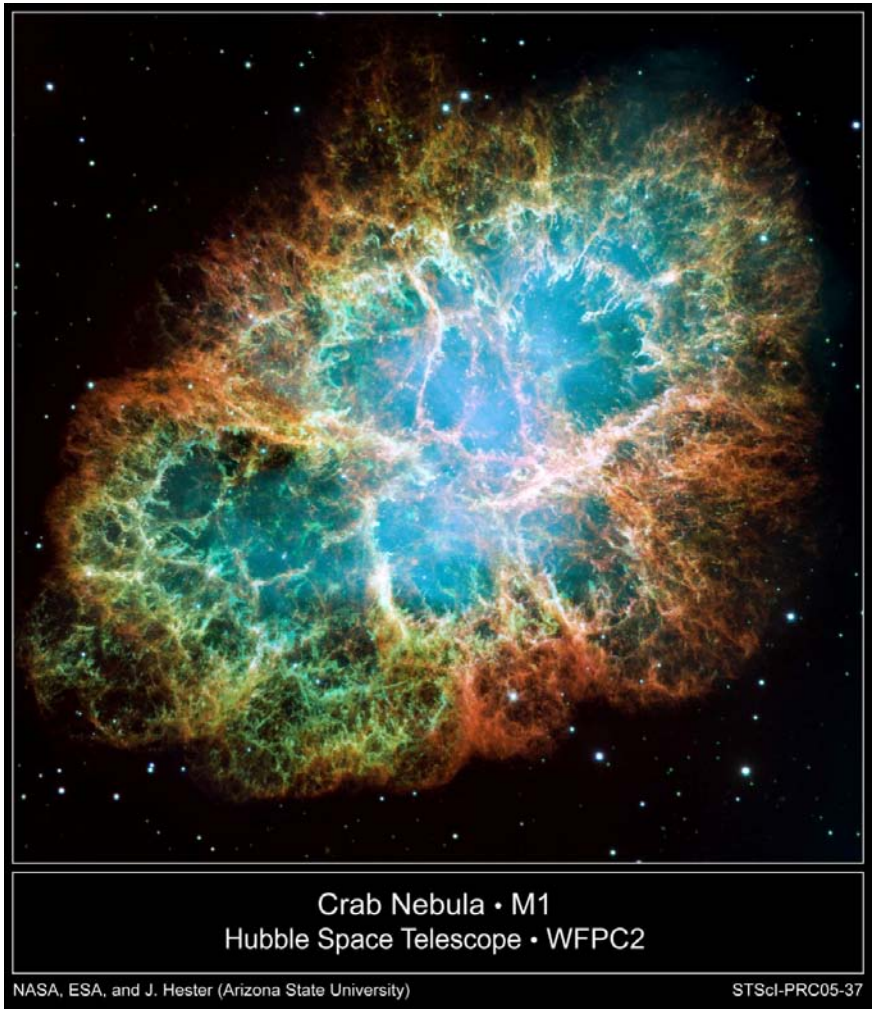
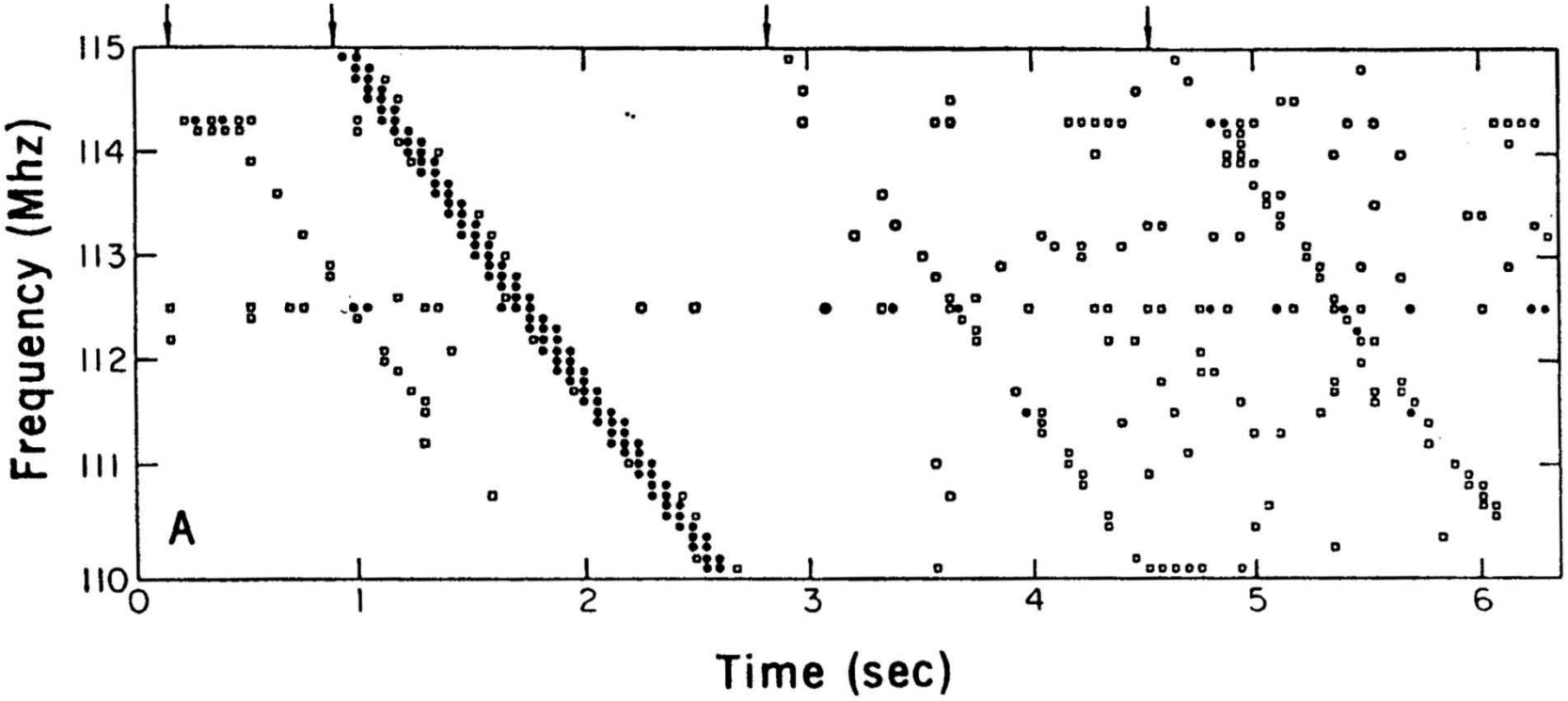


Figure 6

Discovery of Crab Pulsar

GB 300-ft. Telescope, October 1968



Staelin and Reifenstein, "Pulsating Radio Sources Near the Crab Nebula," *Science*, 62, 1481 (Dec. 27, 1968)

Figure 7

Pulsars
A Review by F. Graham-Smith

Reports on Progress in Physics, 35, 399 (1972)

"The most significant discovery since the original Cambridge work then came from the National Radio Astronomy Observatory (NRAO) in USA. Staelin and Reifenstein (1968) found two pulsars close to the Crab nebula, the best known supernova remnant in the whole sky. They could not, however, measure the periods, and it was left to Comella et al. (1969) working with the 1,000-ft. telescope at Arecibo to show that one of these two had a period of only 33 ms and that it appeared to be within the nebula. This pulsar is also slowing down, but so much faster than the Vela pulsar that its age is of the order of only 1,000 years. This is in very good agreement with the known age of the Crab nebula itself, and the association is completely established."

Figure 8