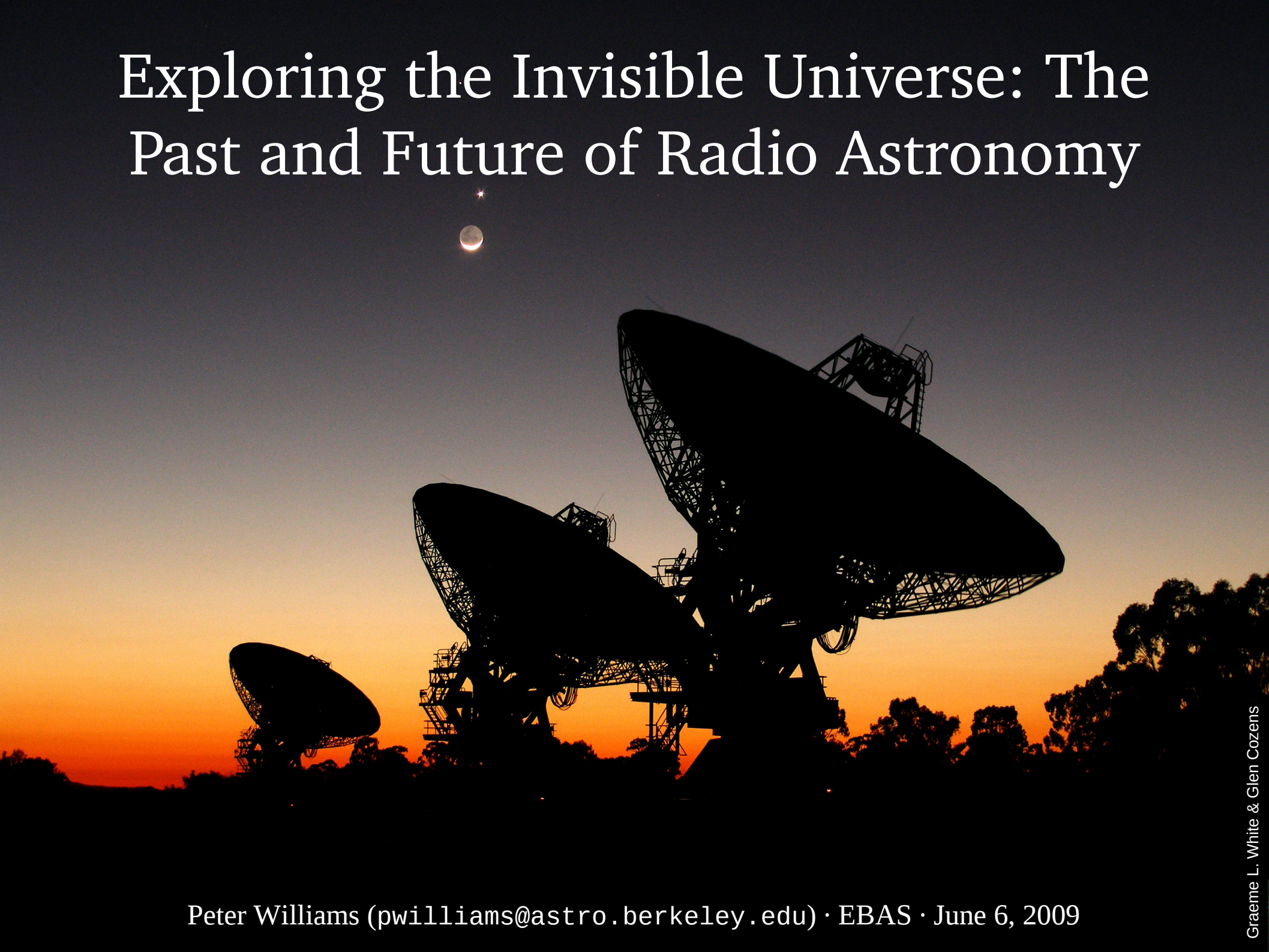
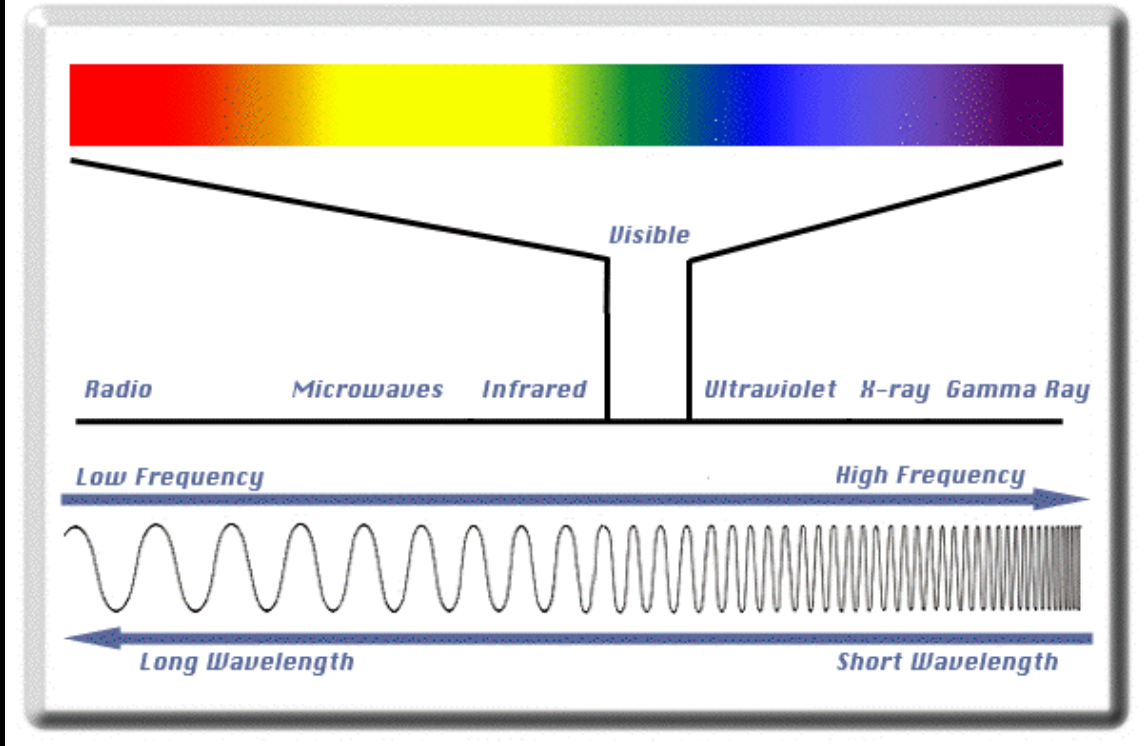
Exploring the Invisible Universe: The Past and Future of Radio Astronomy

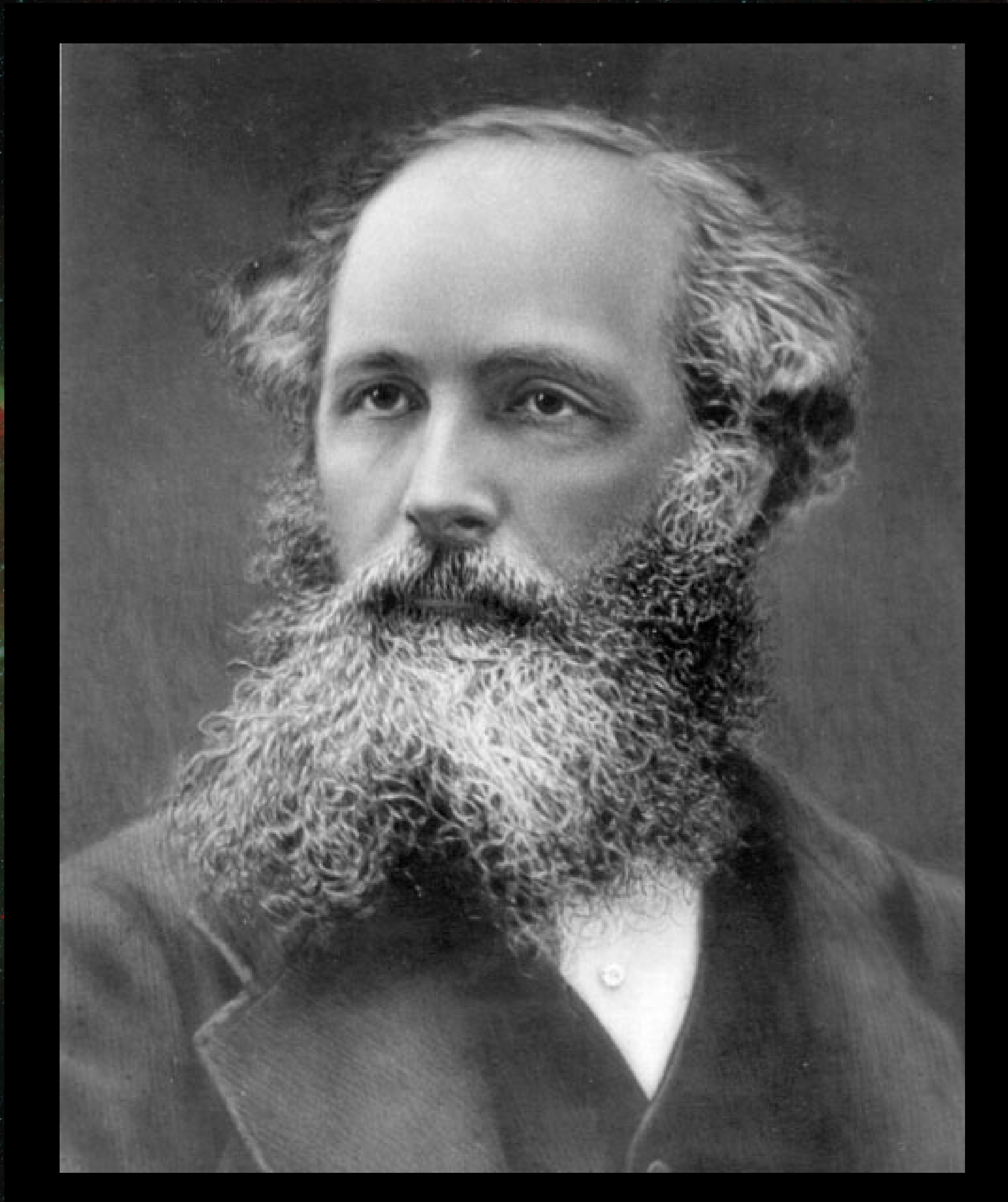


Peter Williams (pwilliams@astro.berkeley.edu) · EBAS · June 6, 2009

Graeme L. White & Glen Cozens

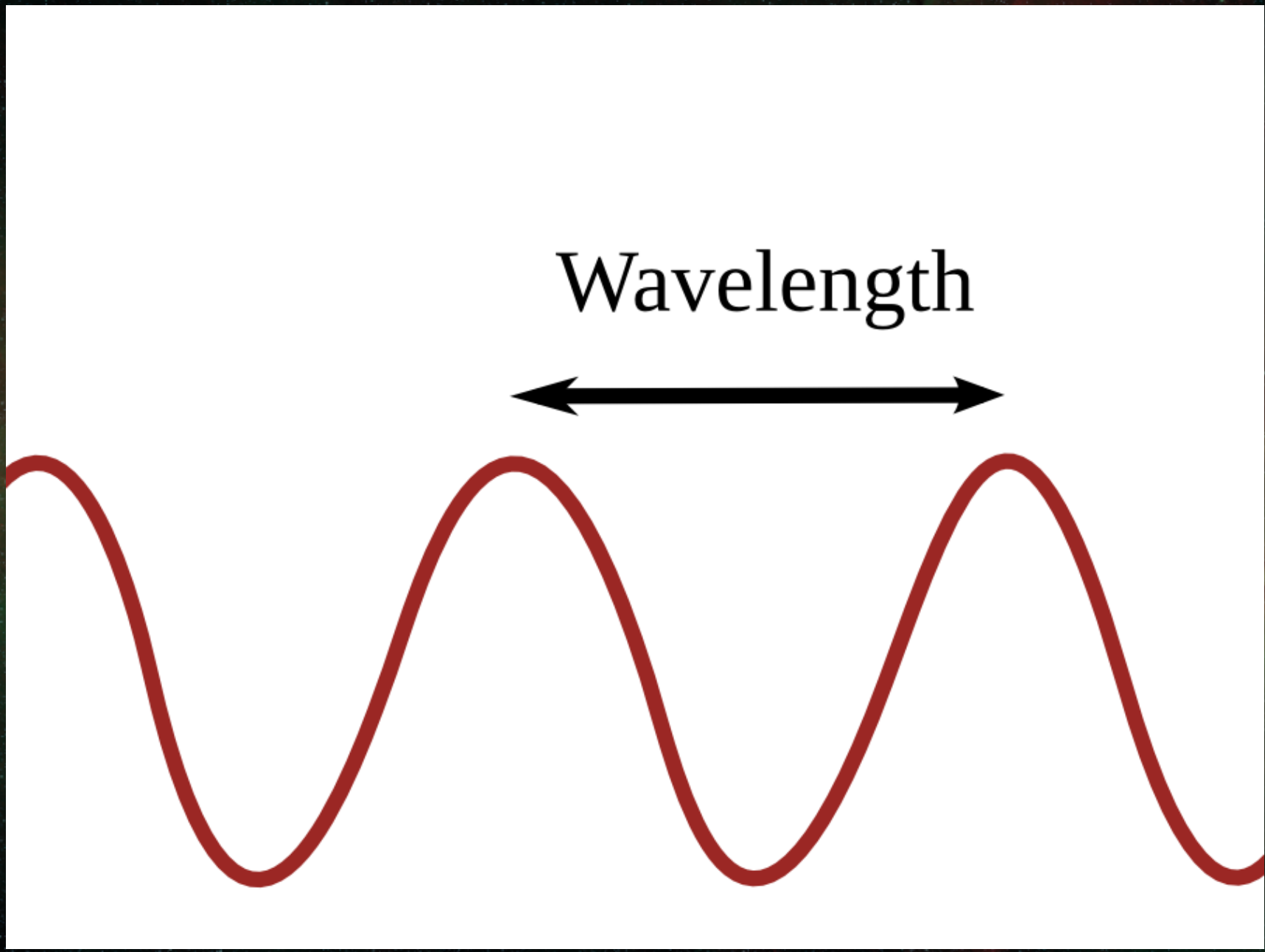
I. Radio Waves


Visible
Radio
Microwaves
Infrared
Ultraviolet
X-ray
Gamma Ray
Low Frequency
High Frequency
Long Wavelength
Short Wavelength

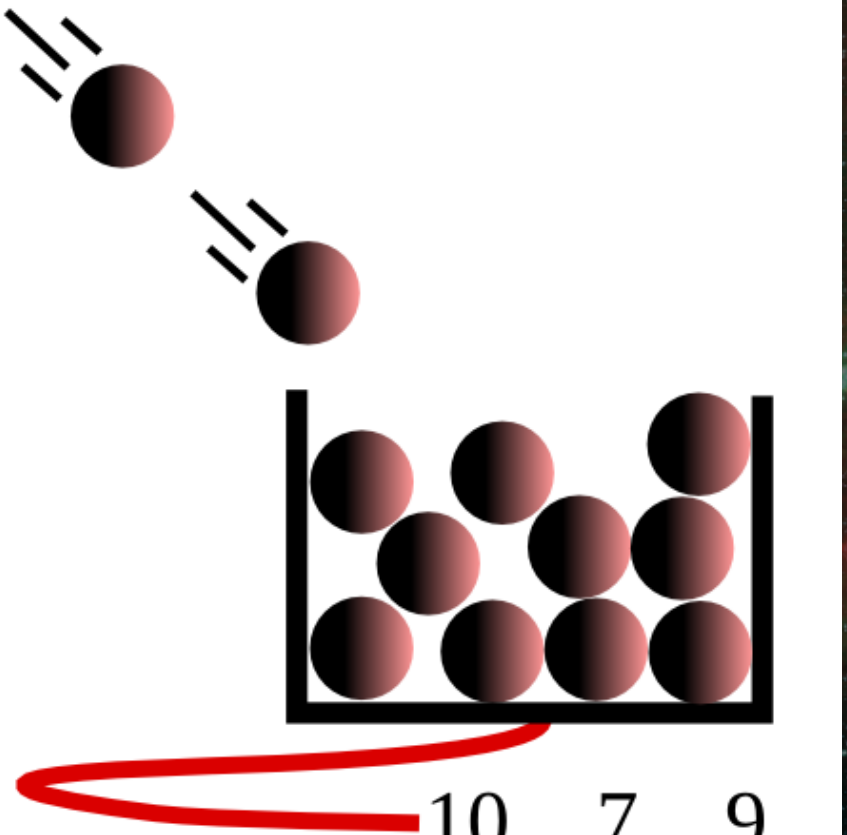


$$\nabla \cdot E = \rho \qquad \nabla \cdot B = 0$$

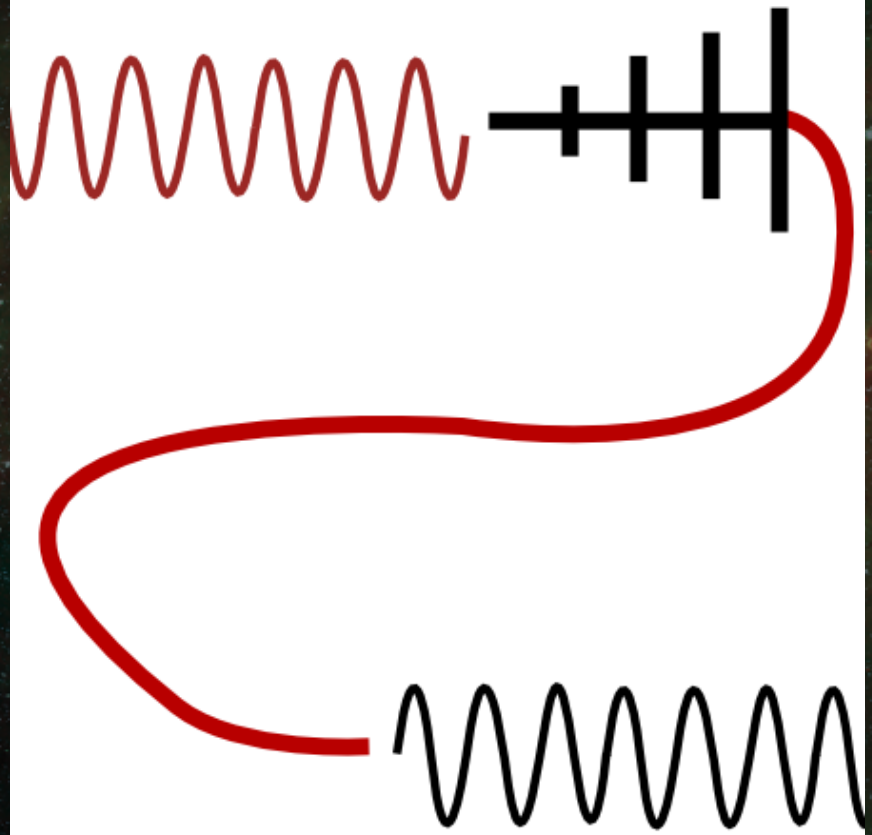
$$\nabla \times E = -\frac{\partial B}{\partial t} \qquad \nabla \times B = J + \frac{\partial E}{\partial t}$$

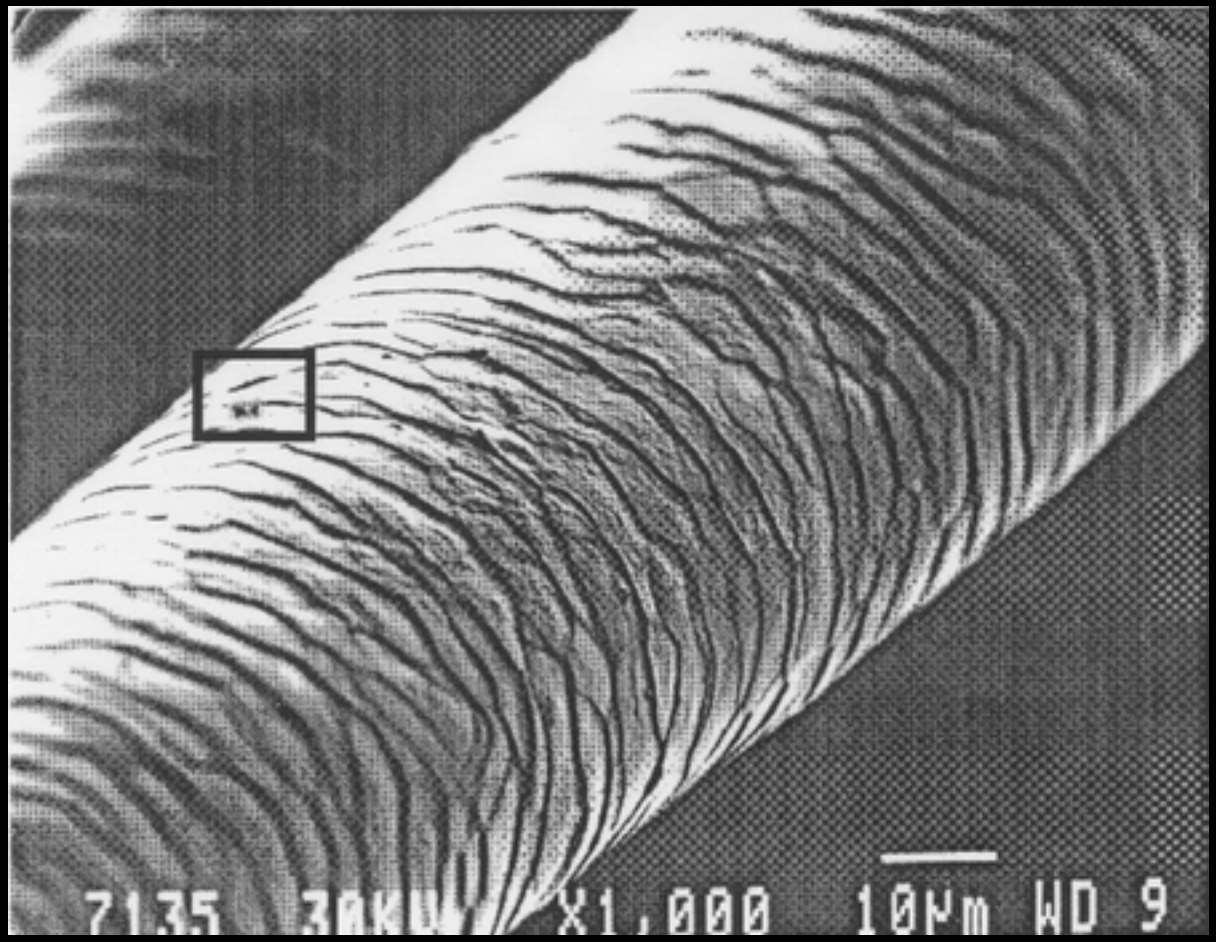

Wavelength

Optical: photon



Radio: wave





masonworld.com / Siemens

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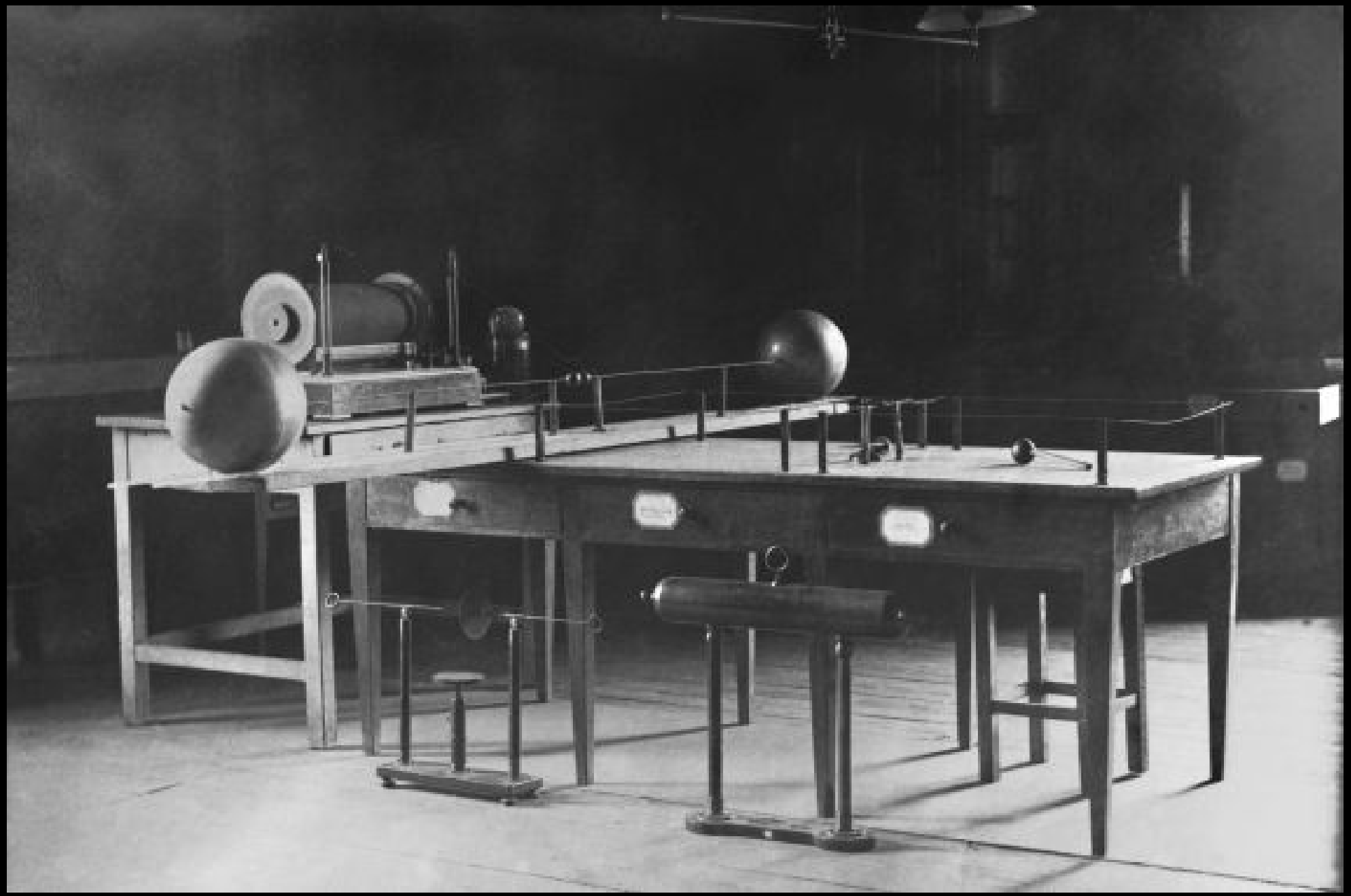
II. The First Radio Observations

nrao.edu, original source unknown

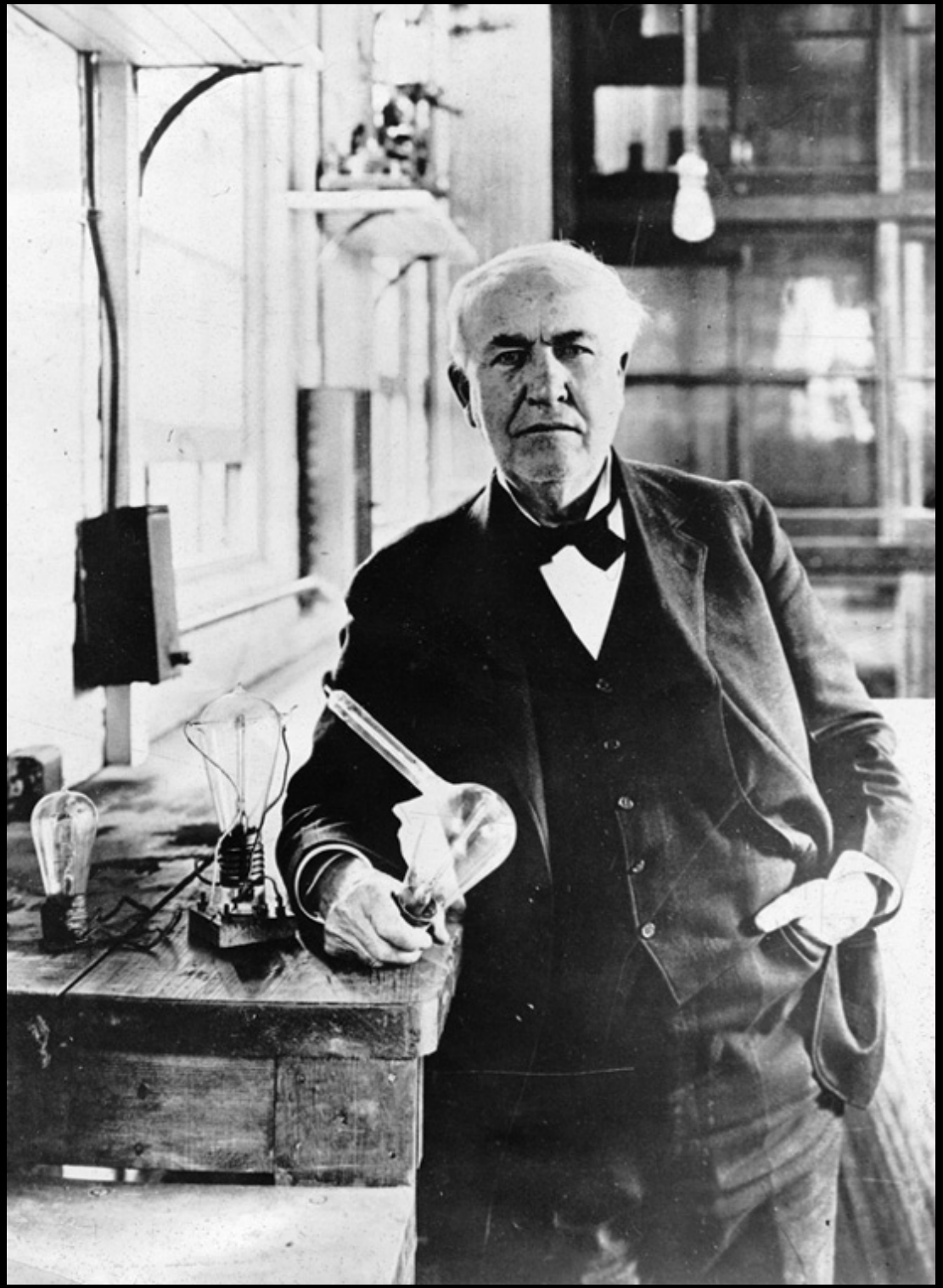


"It's of no use whatsoever. This is just an experiment that proves Maestro Maxwell was right - we just have these mysterious electromagnetic waves that we cannot see with the naked eye. But they are there."

"So, what next?"

“Nothing, I guess."

http://chem.ch.huji.ac.il/history/hertz.htm



National Archives

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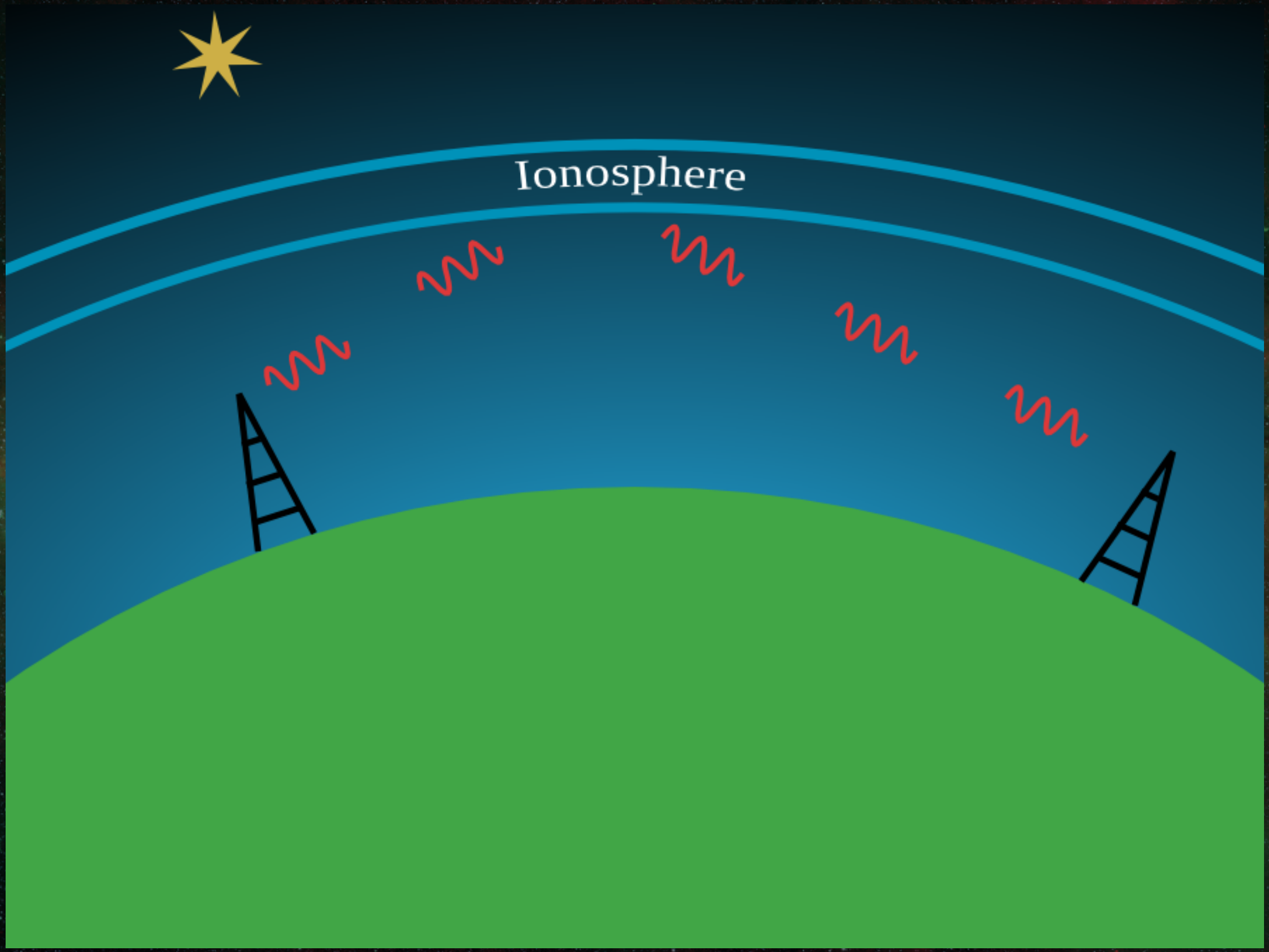
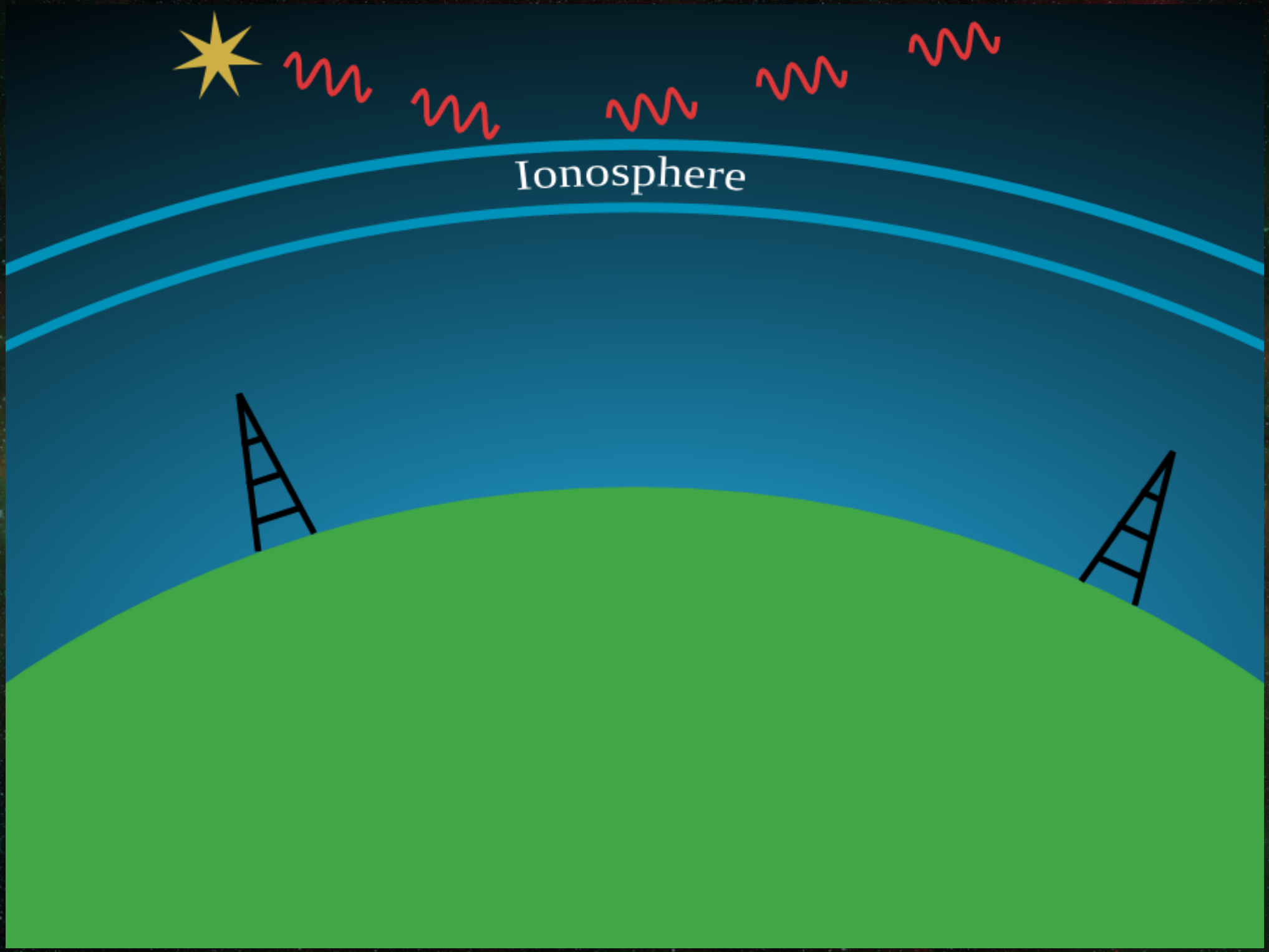

Ionosphere


Ionosphere

eecs.berkeley.edu, original unknown

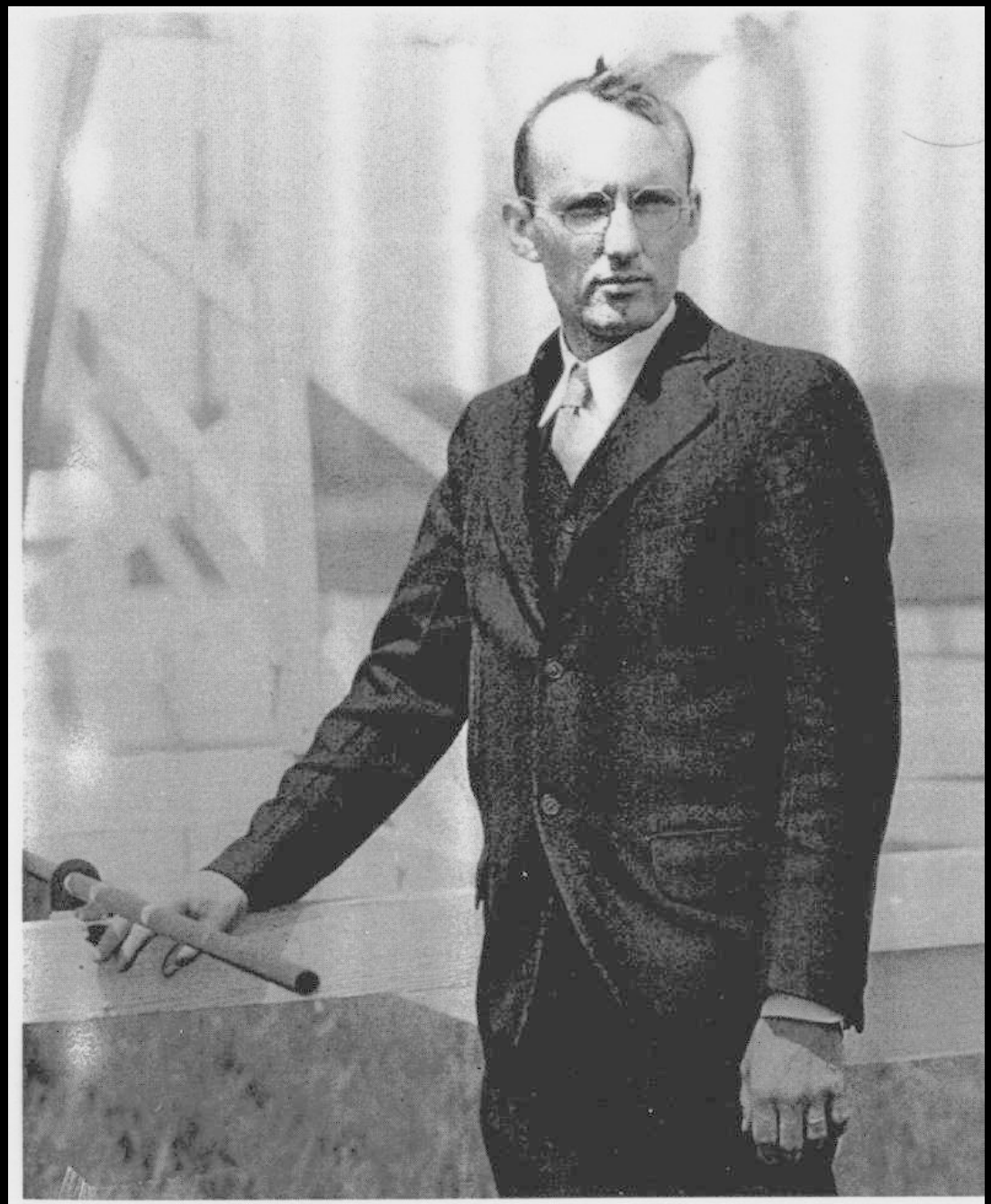
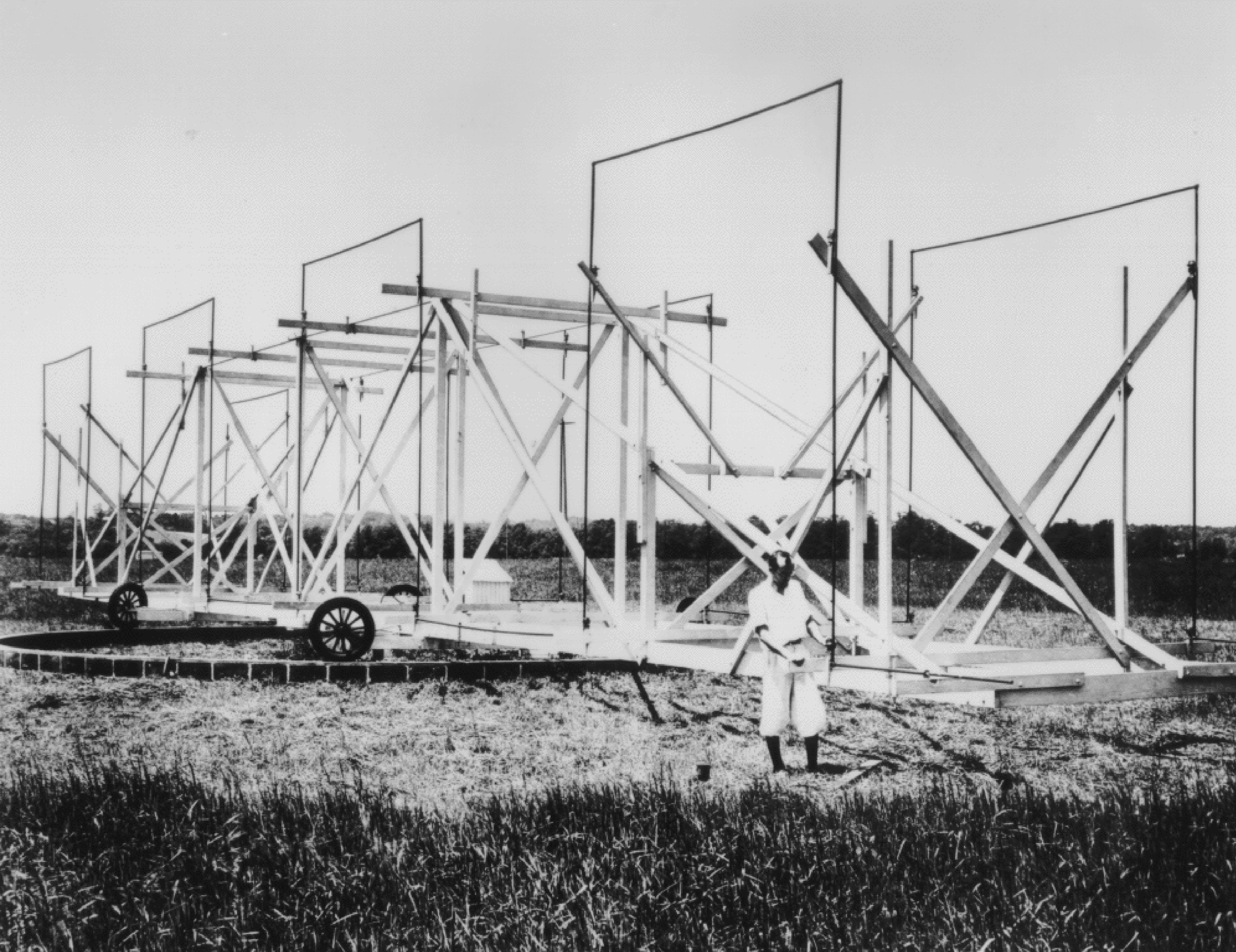
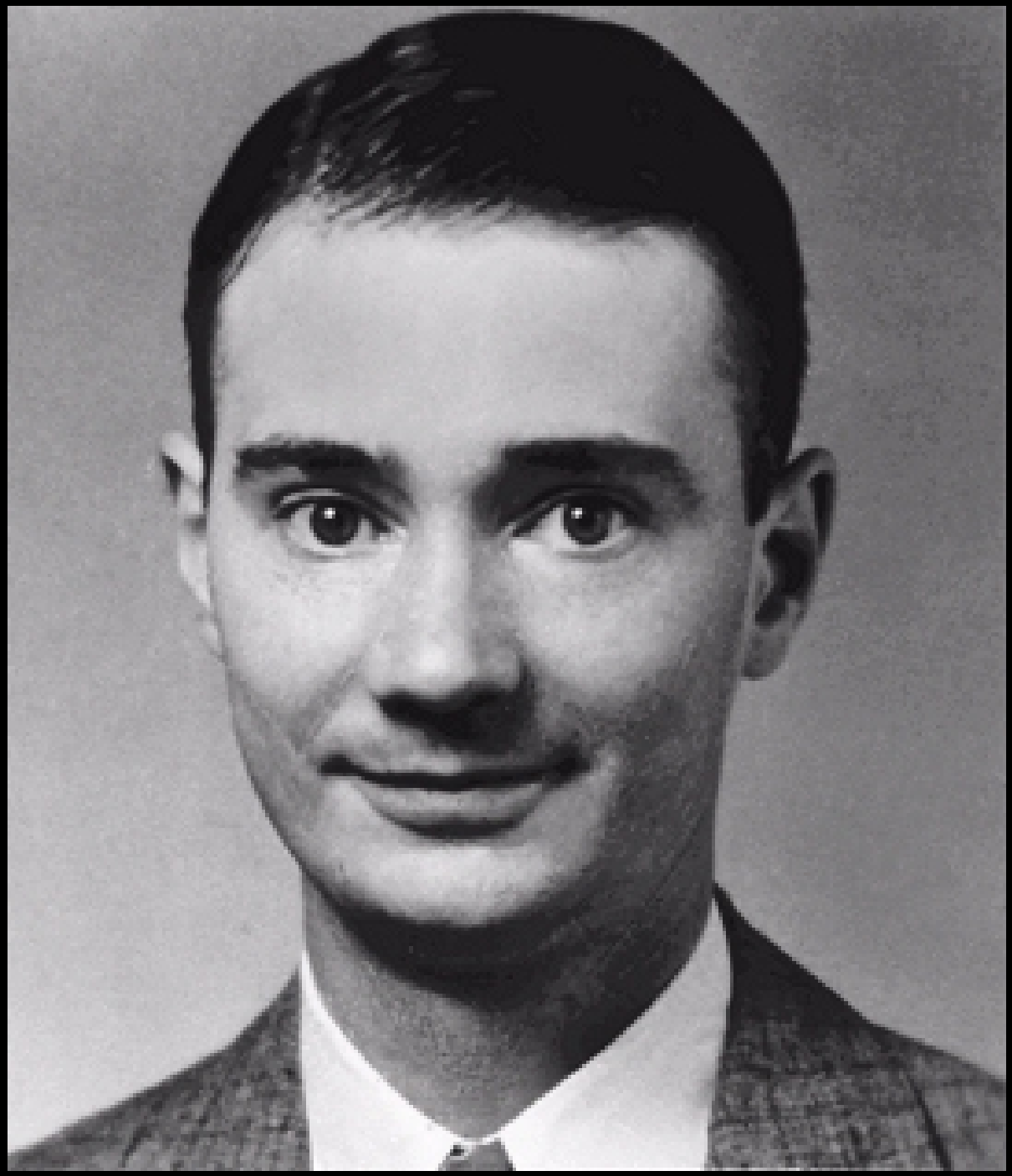
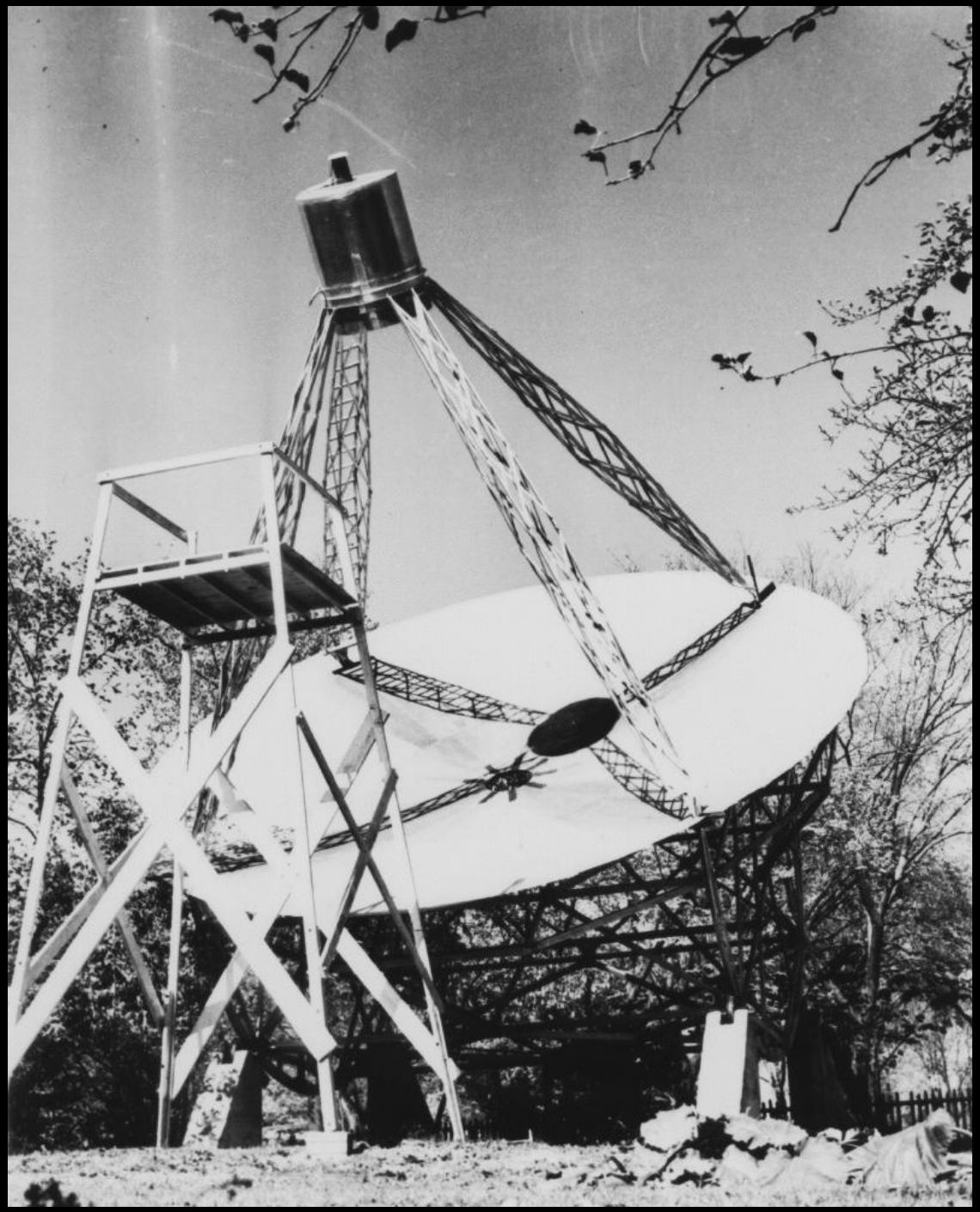


FIG. 1—Karl Guthe Jansky, about 1933.





J.Roy.Ast.Soc of Canada, 1988, 82, 93



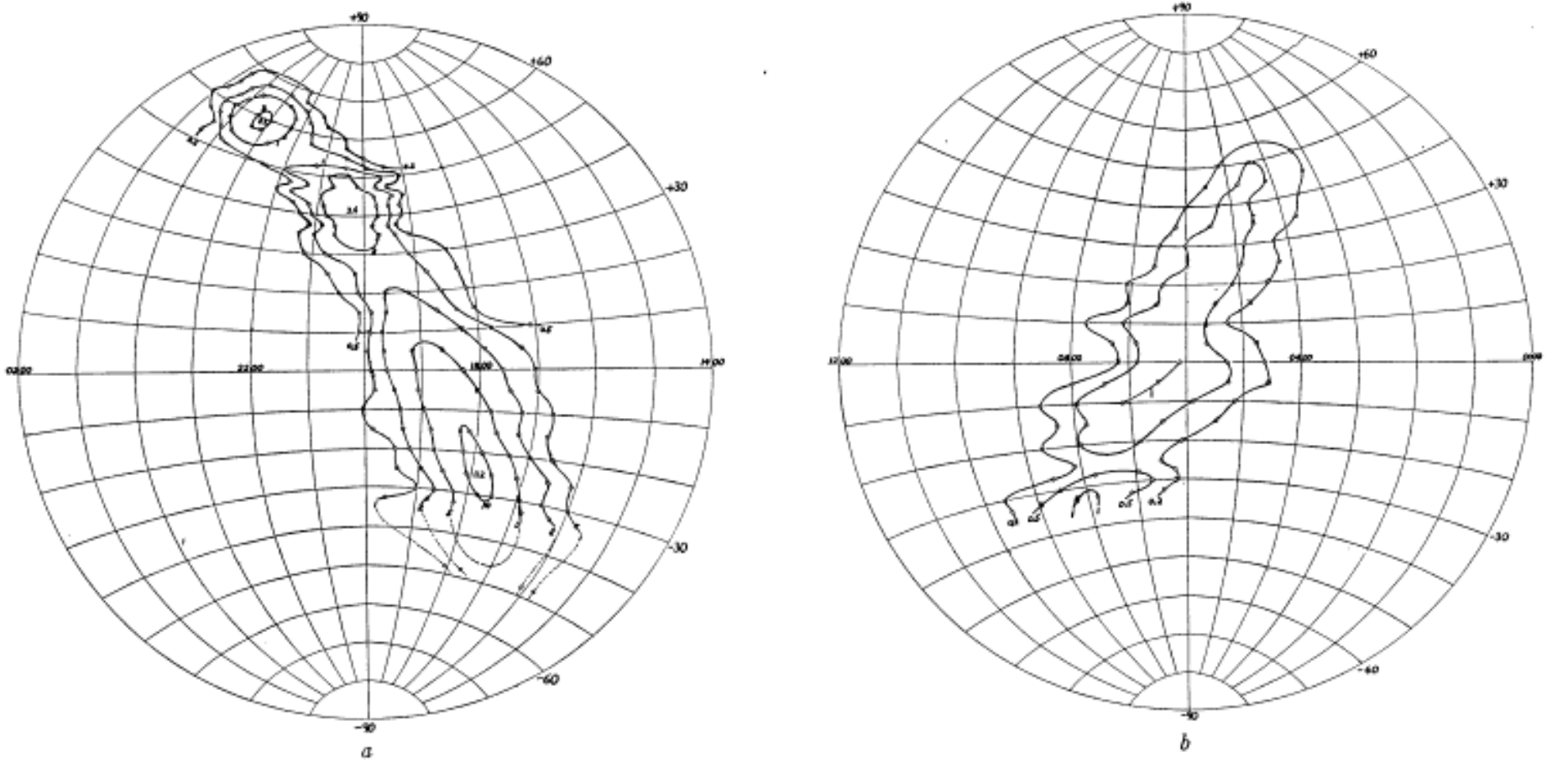
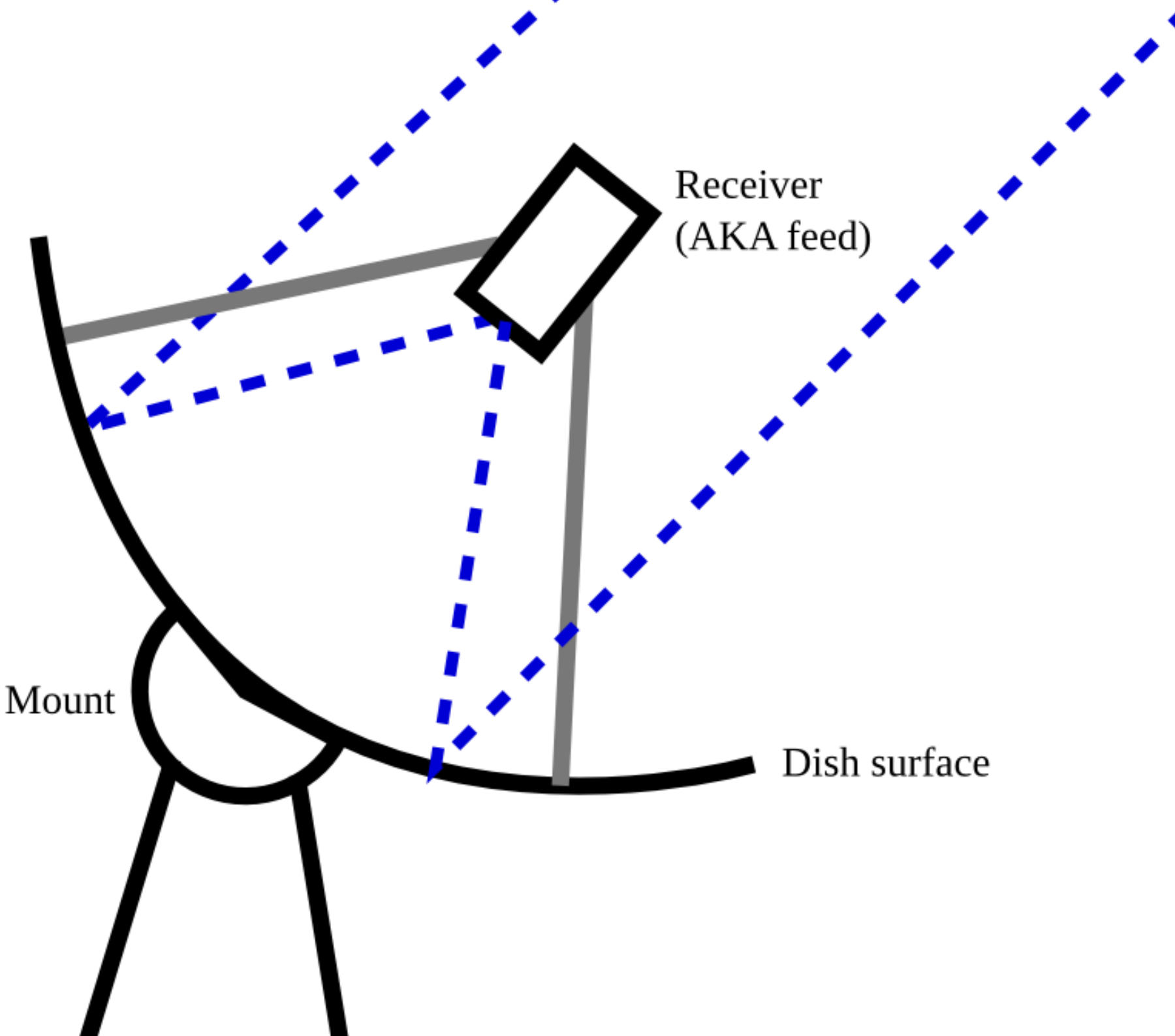
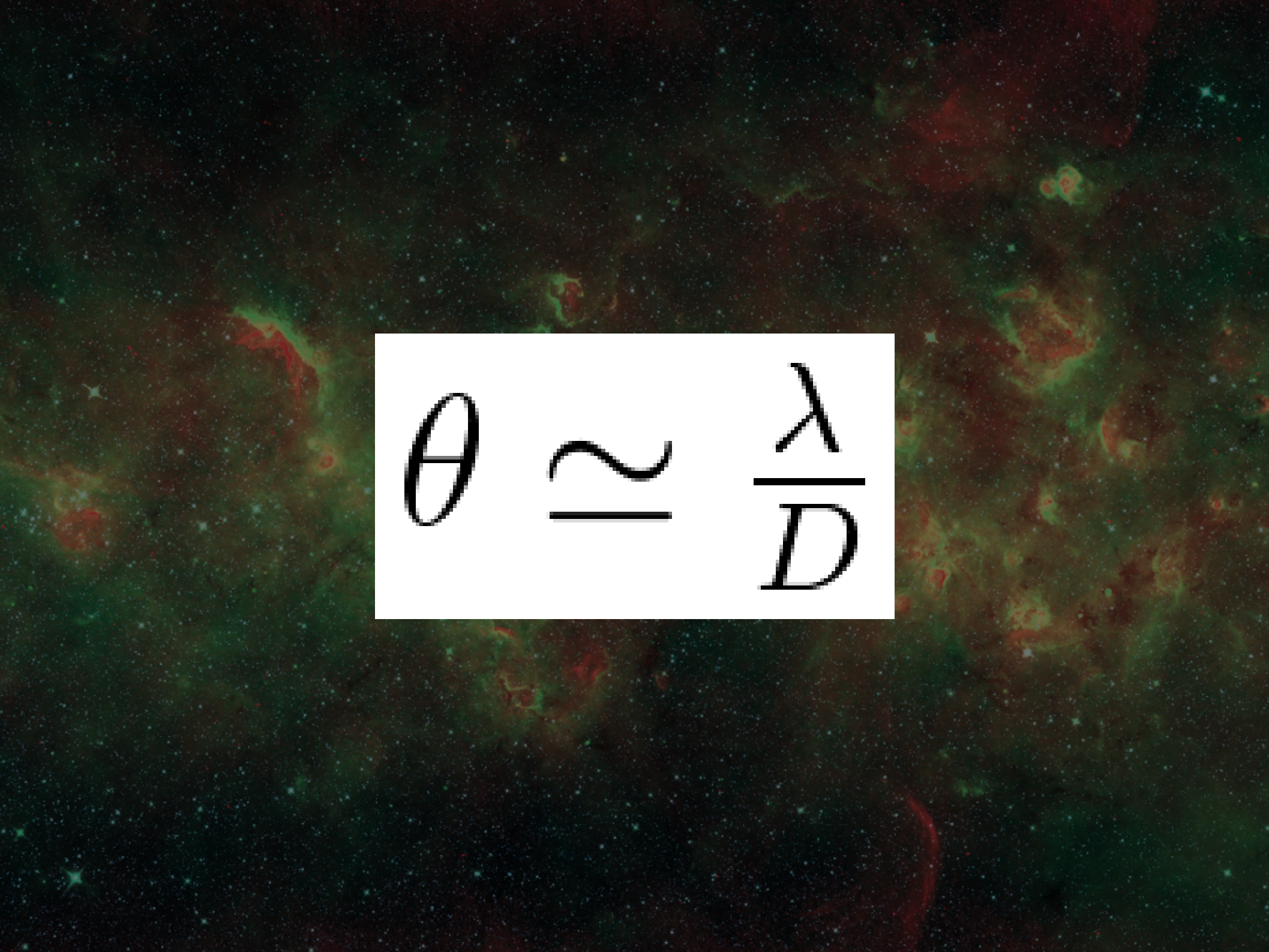


FIG. 4.—Constant intensity lines in terms of 10^{-22} watt/sq. cm./cir. deg./M.C. band

III. Early Single-Dish Radio Astronomy


Receiver
(AKA feed)
Mount
Dish surface


$$\theta \simeq \frac{\lambda}{D}$$

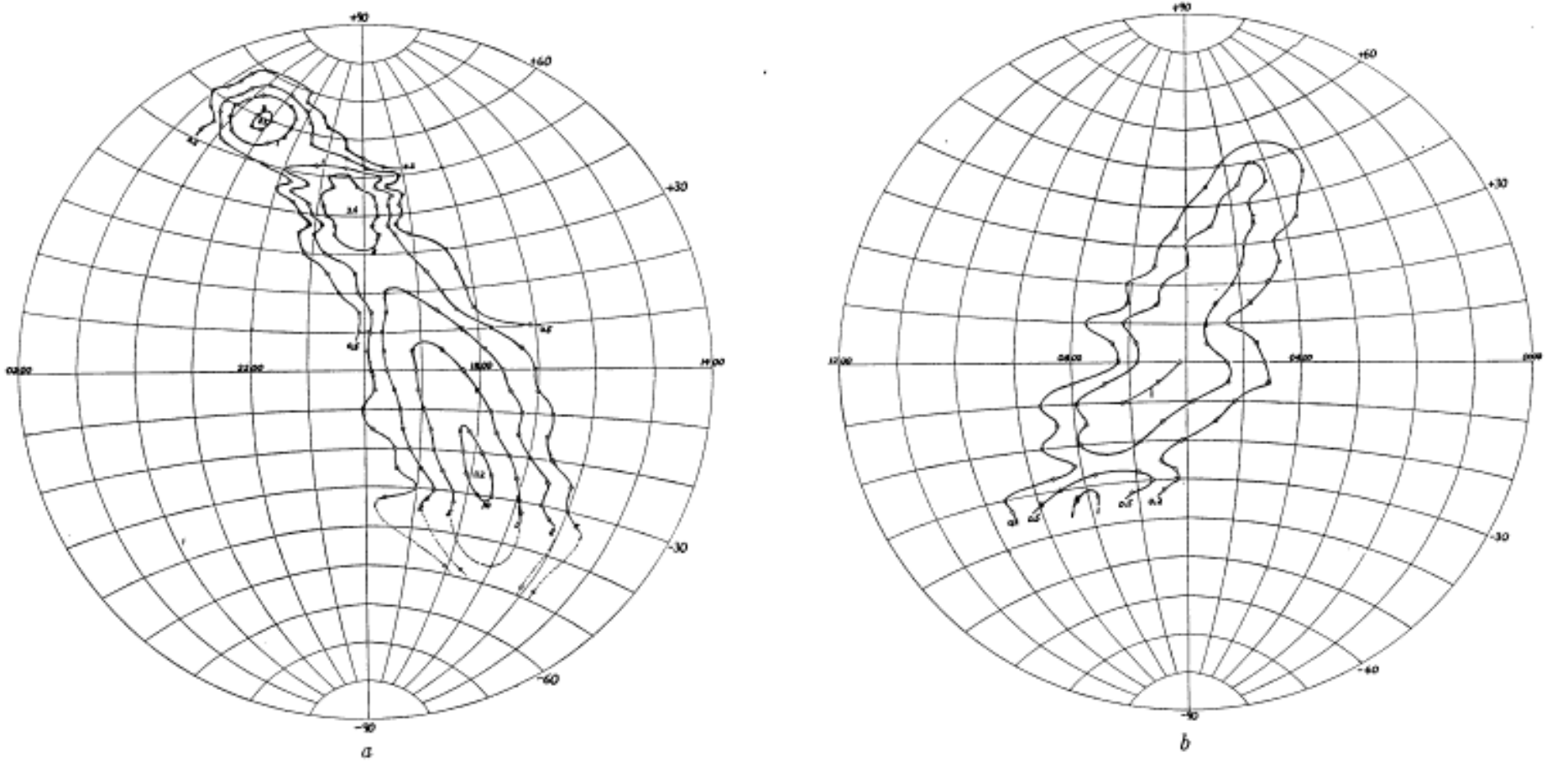
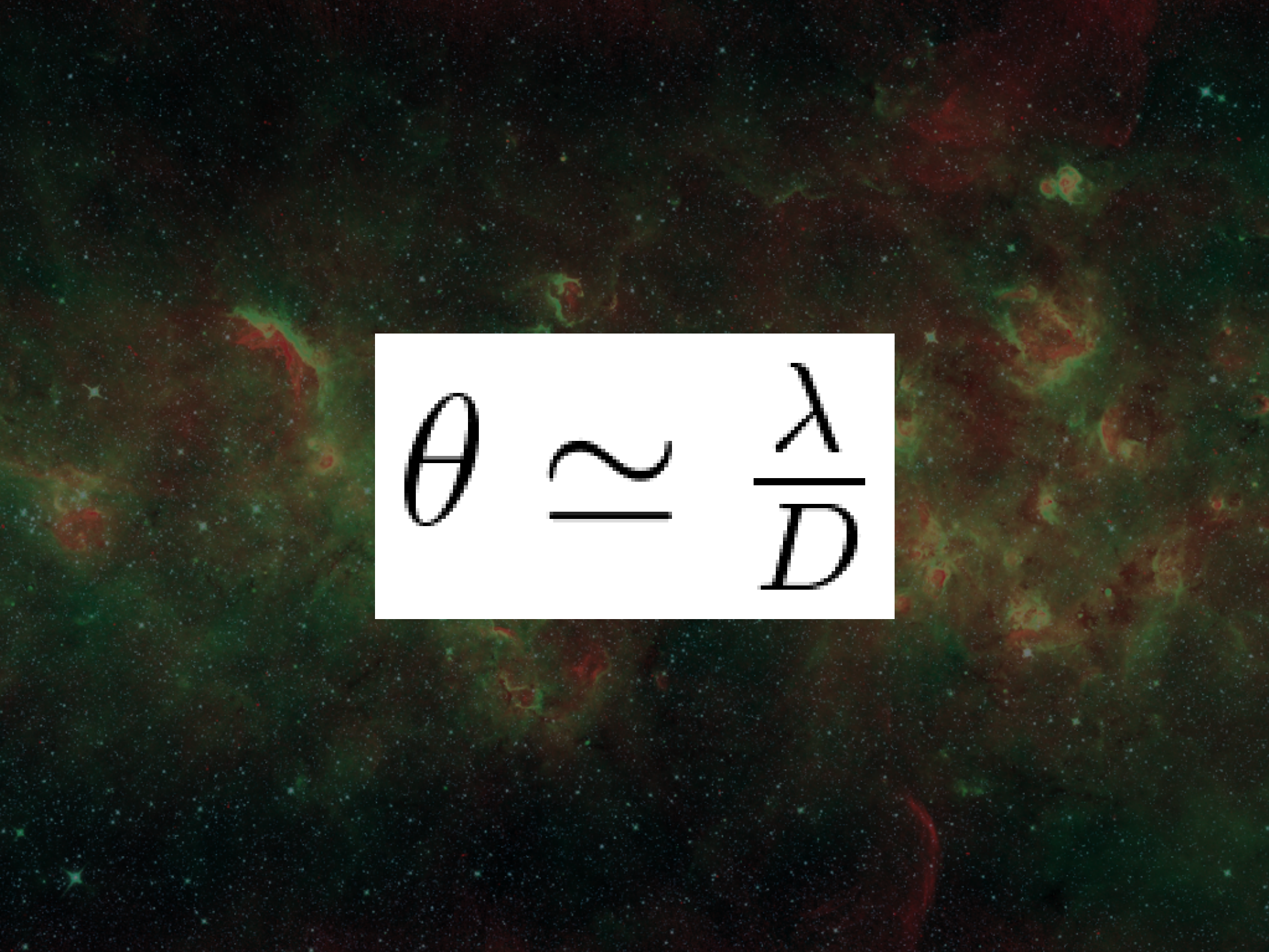
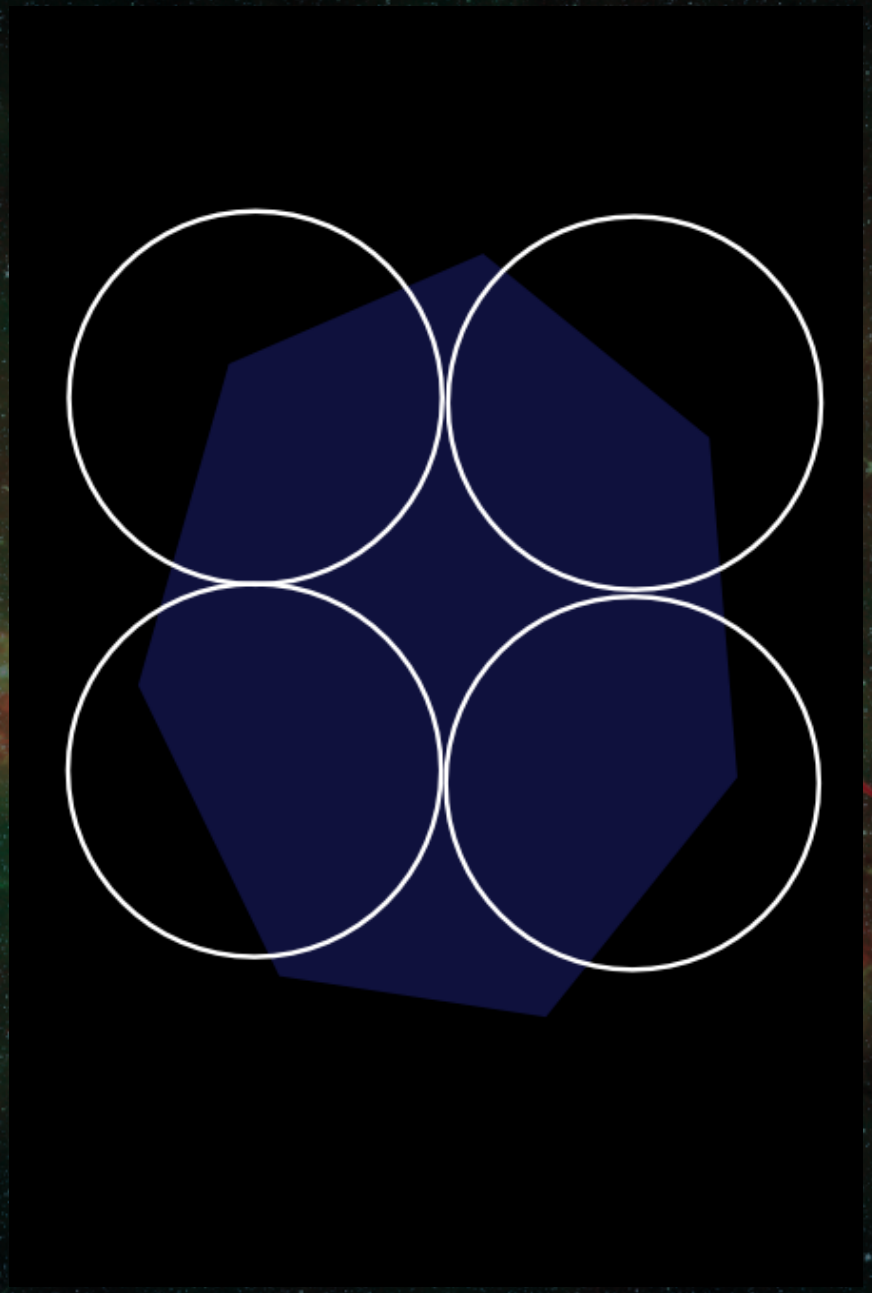
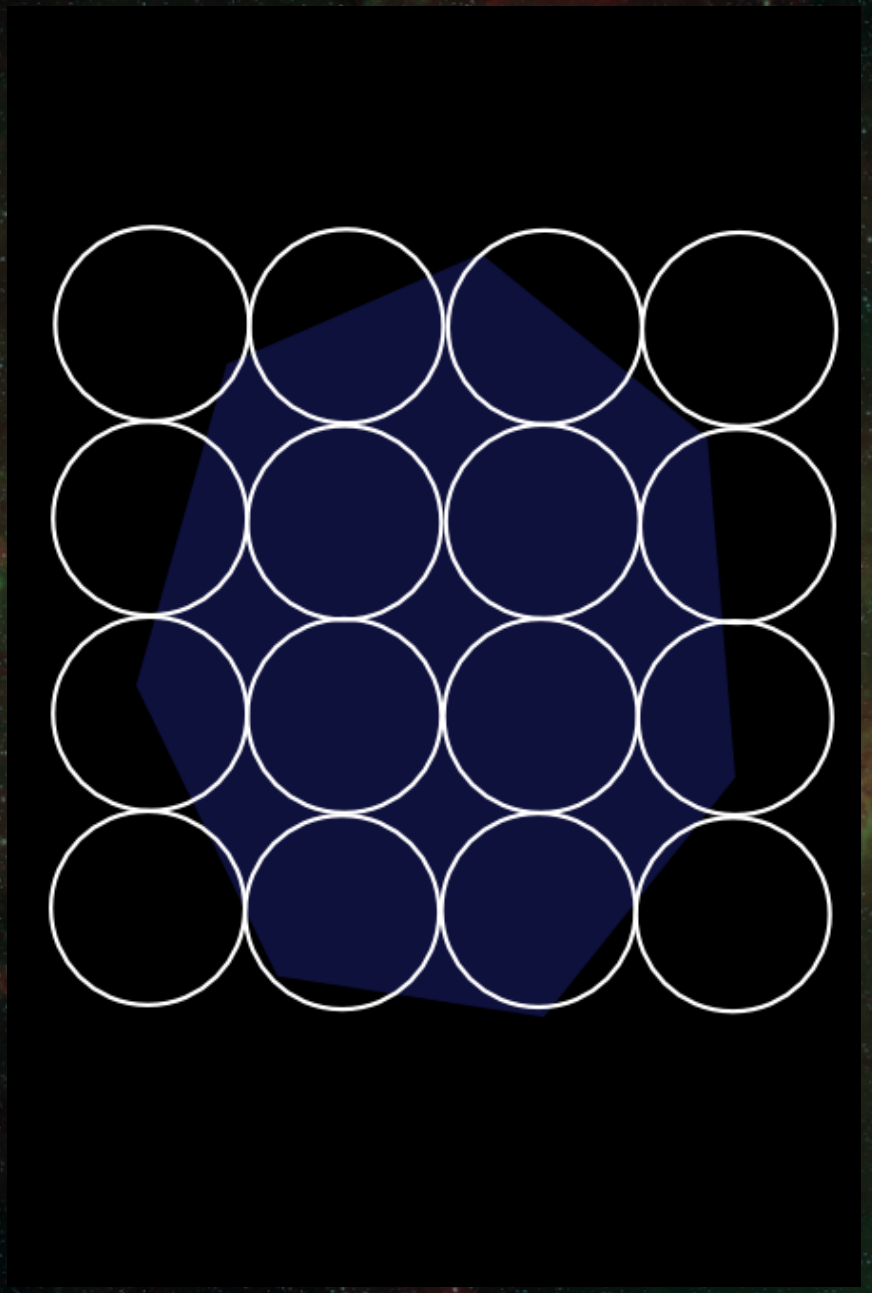


FIG. 4.—Constant intensity lines in terms of 10^{-22} watt/sq. cm./cir. deg./M.C. band


$$\theta \simeq \frac{\lambda}{D}$$





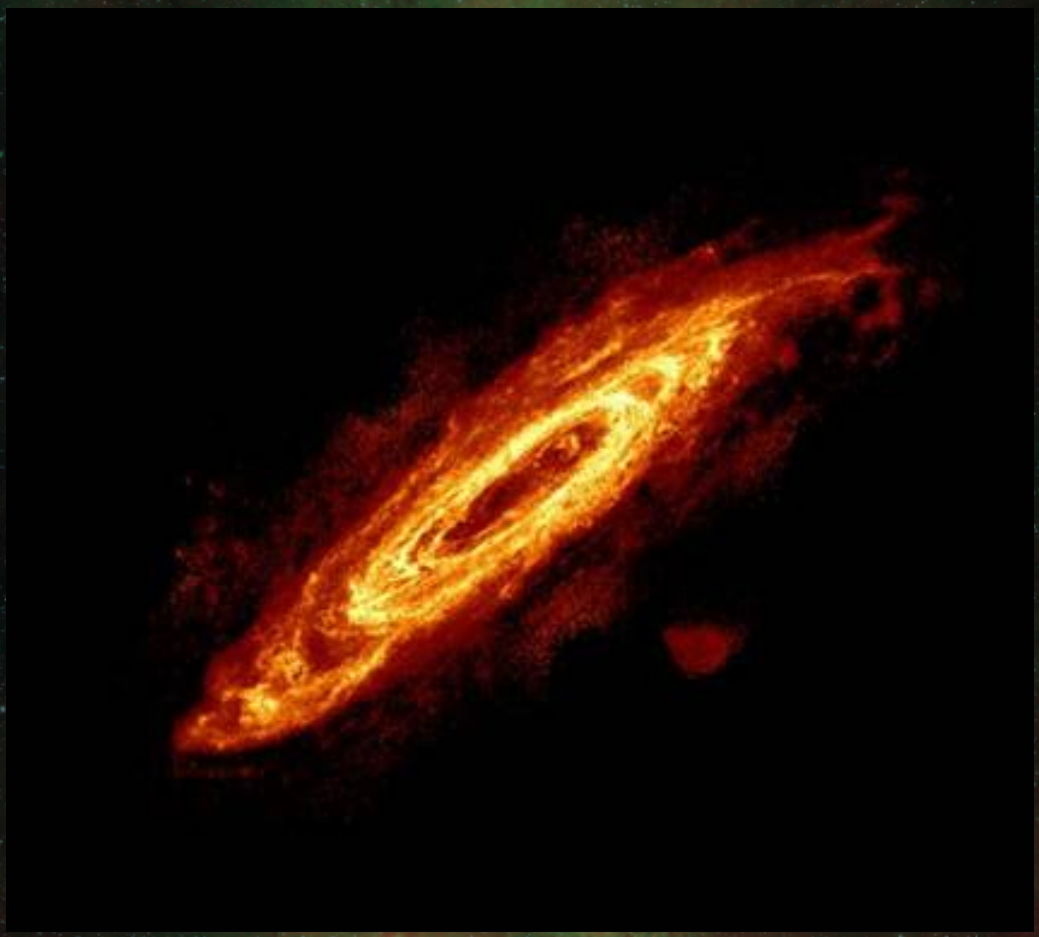
crya.unam.mx, origin unknown

ESO/IDA/Danish 1.5 m/R. Gendler, J.-E. Ovaldsen & S. Guisard (ESO)

Plate 1.6 Van de Hulst reading his paper on the 21 cm hydrogen line. (This photograph taken in 1955 is a reconstruction of the 1944 meeting). (*By courtesy of H. C. van de Hulst, Leiden*)

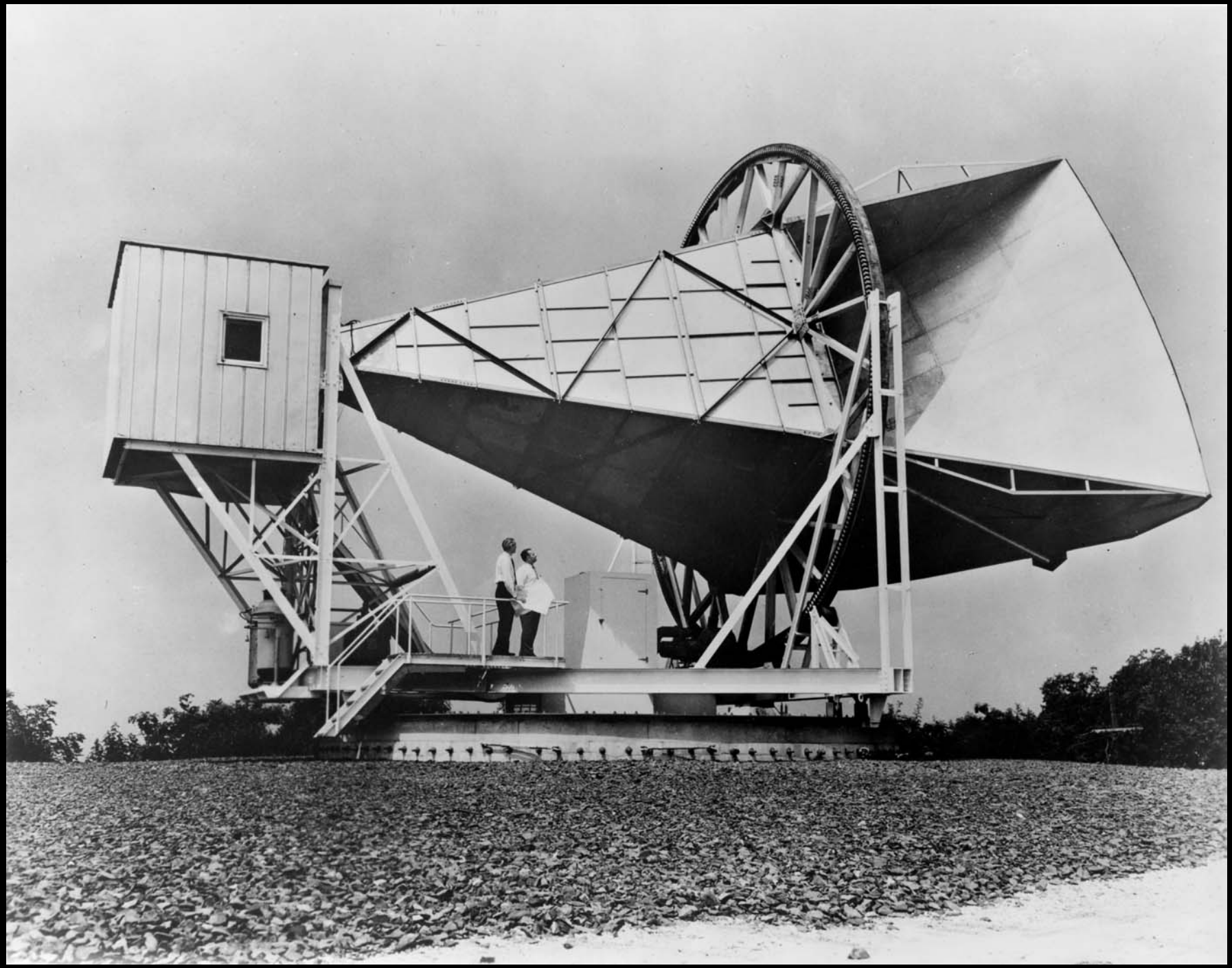

Doc Ewen, NRAO/AUI

Doc Ewen

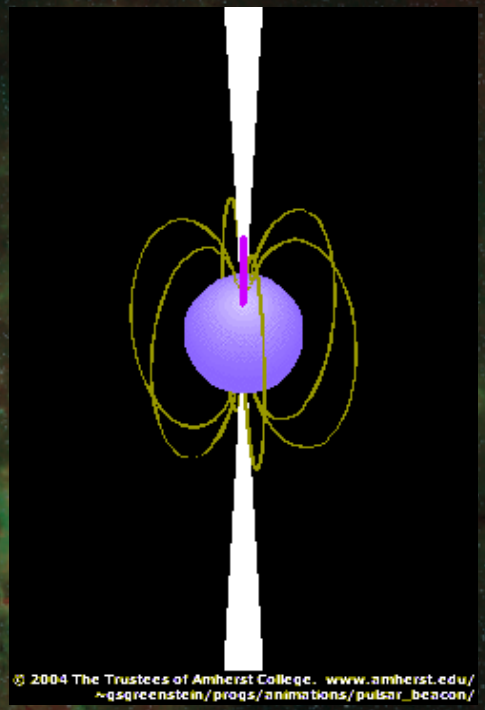


Robert Braun

Life

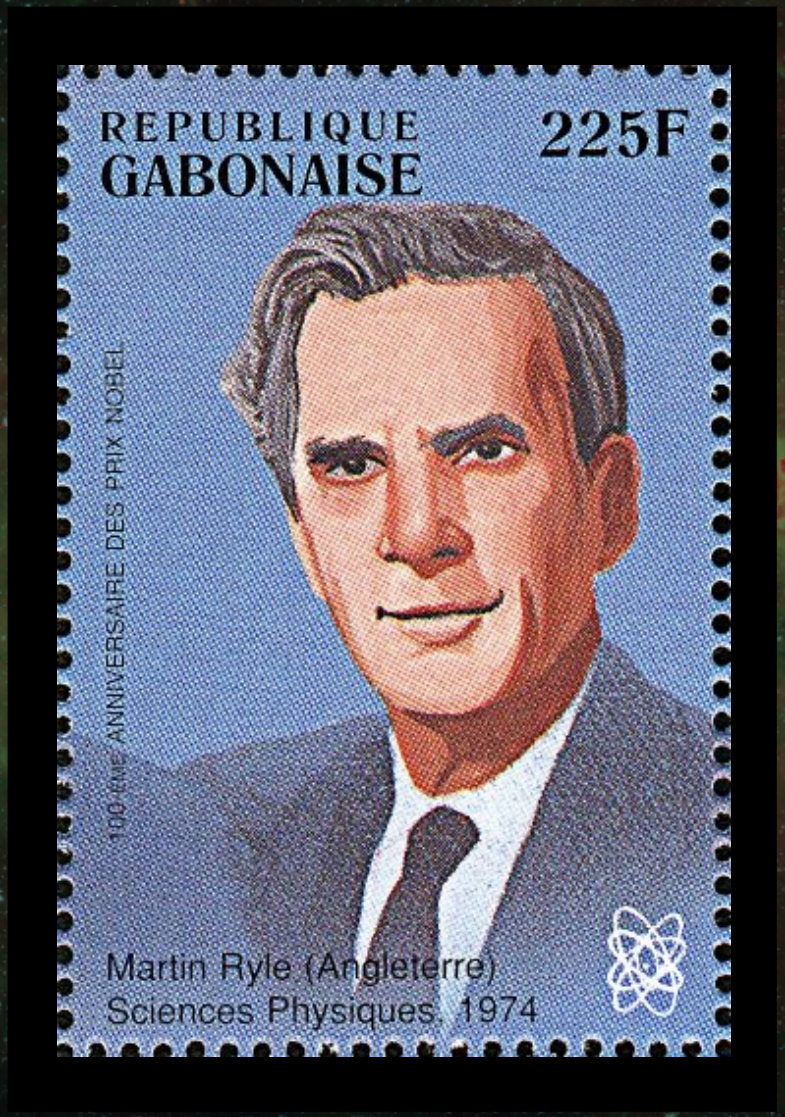


guatesciencia.files.wordpress.com, origin unknown

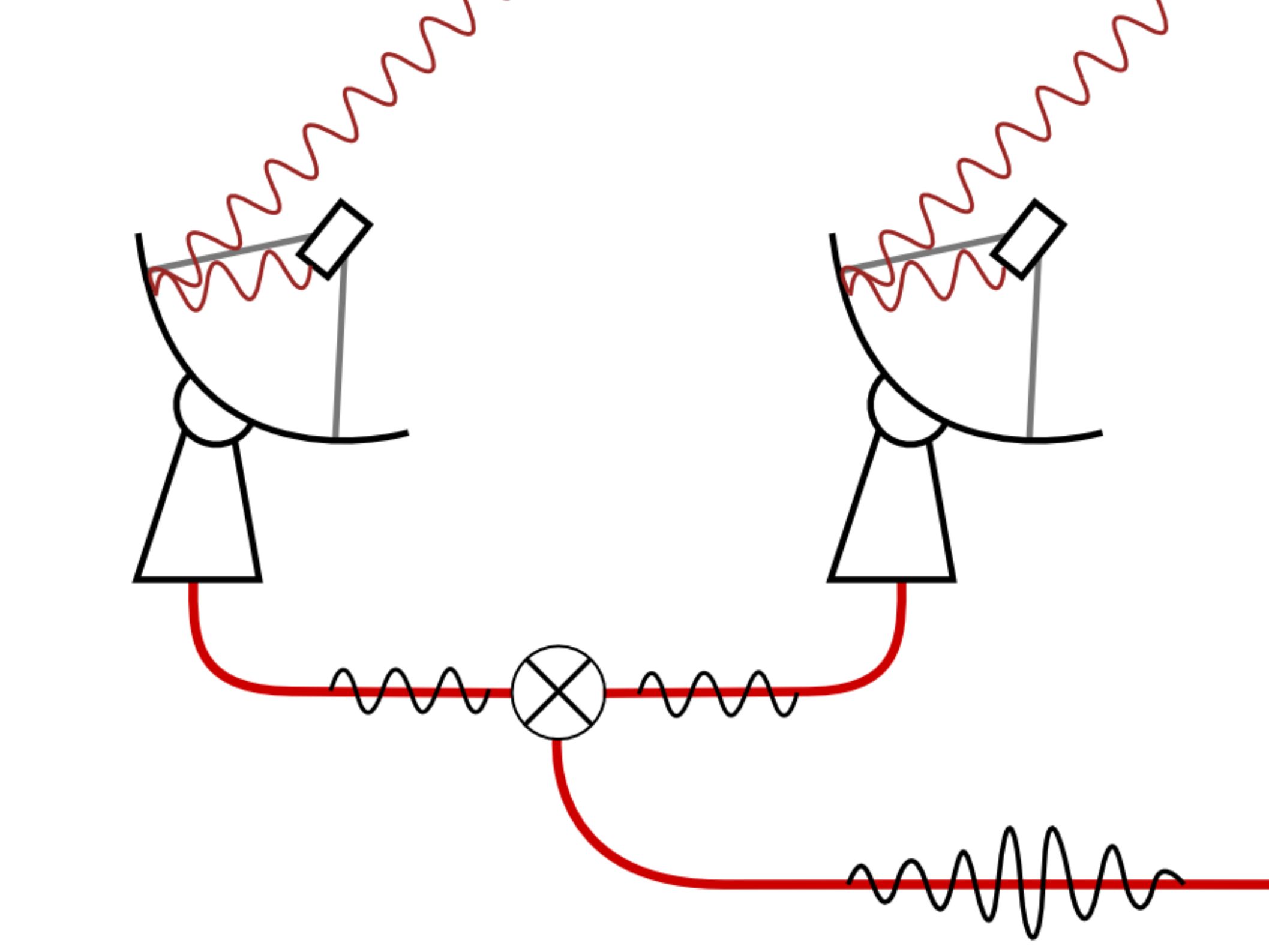


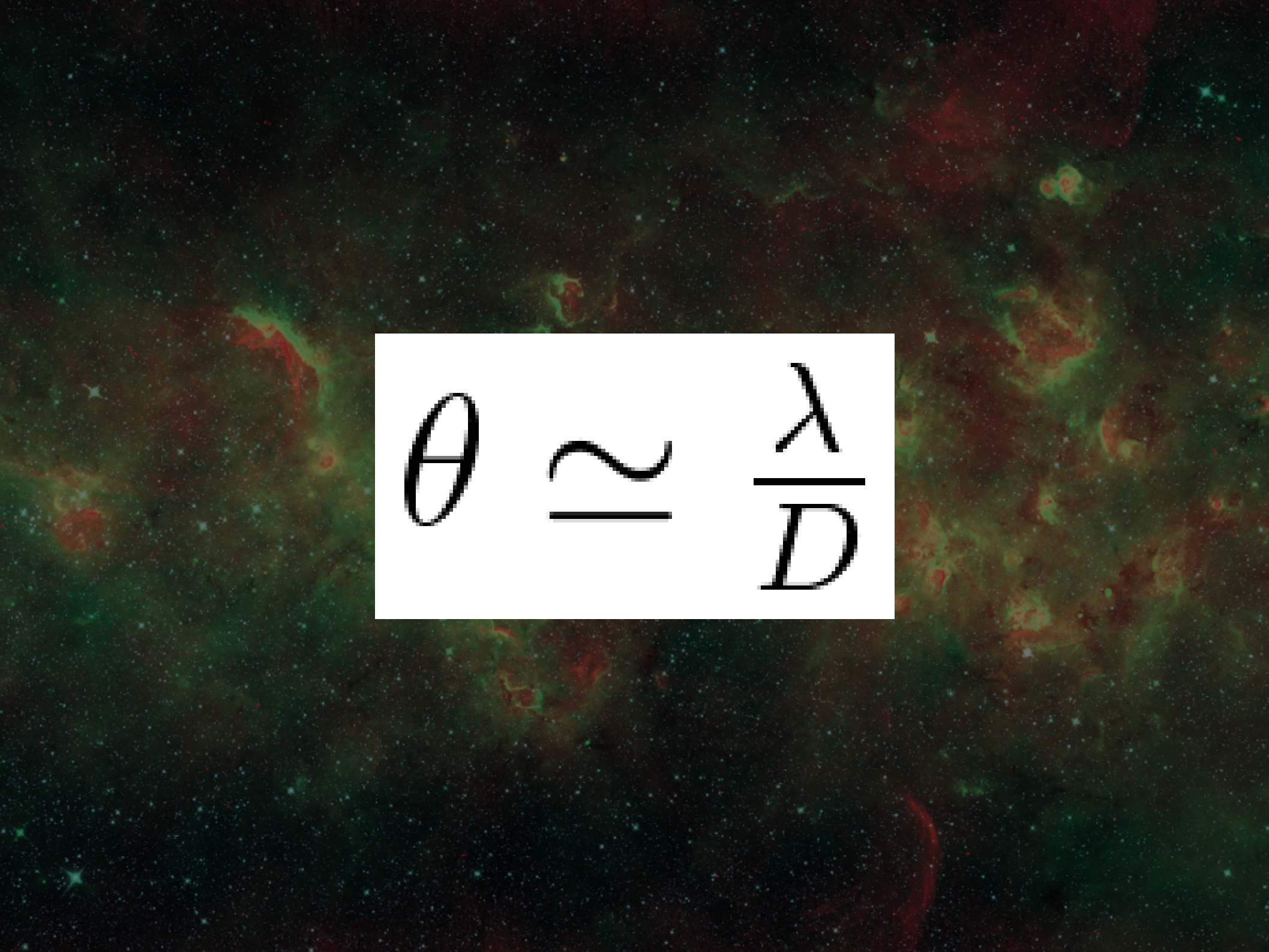
G. S. Greenstein, Amherst College

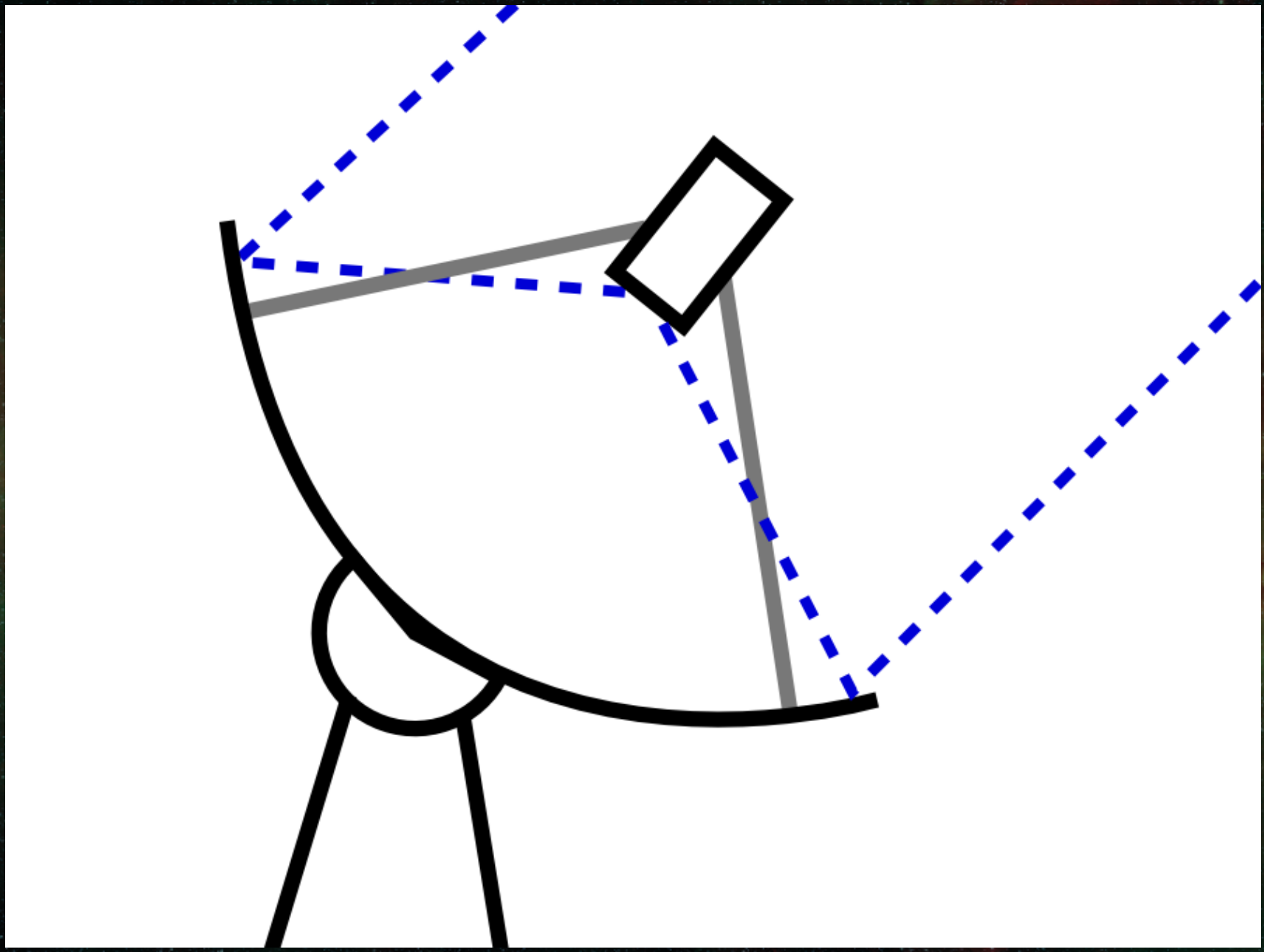
IV. Interferometry

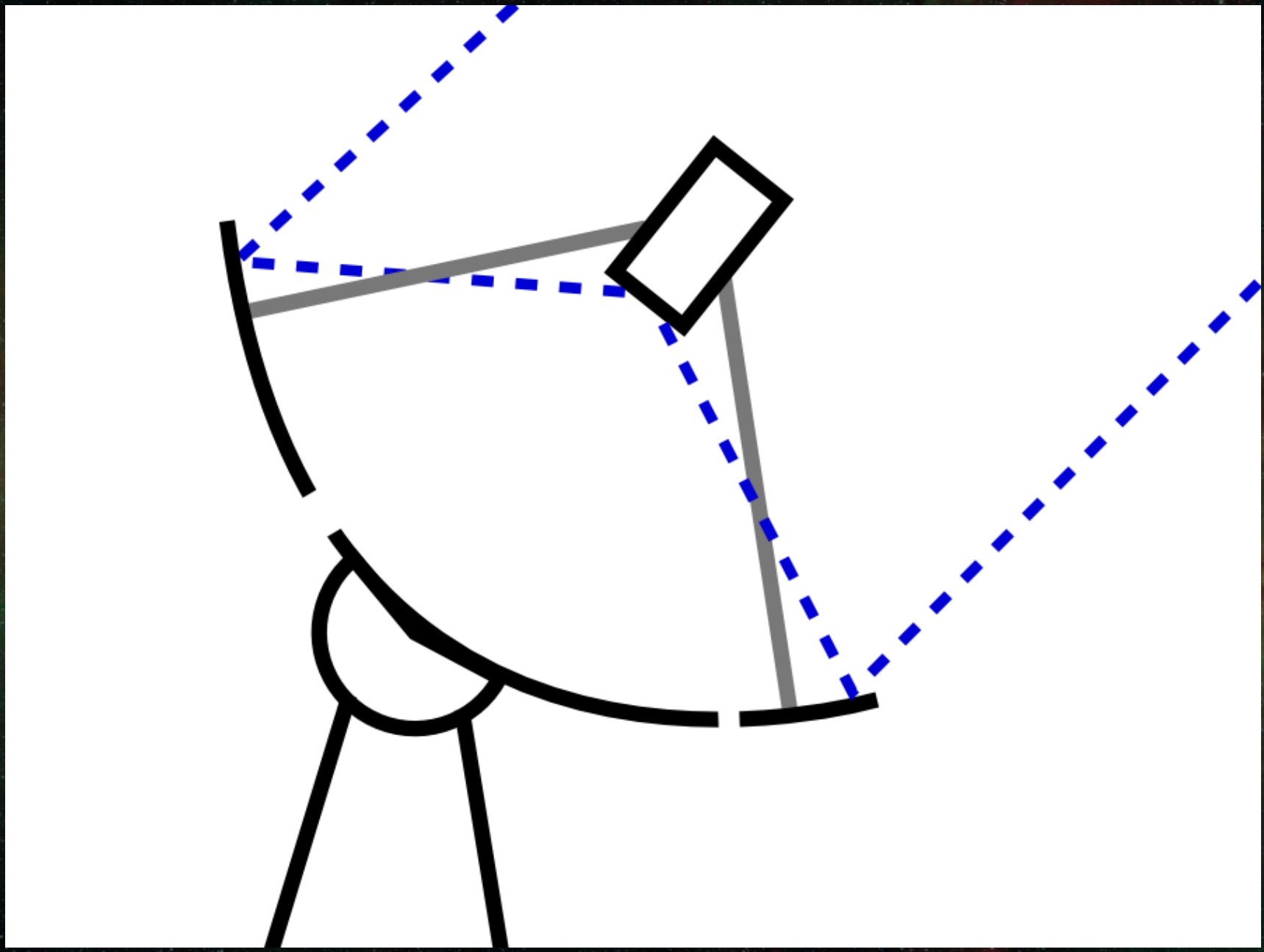


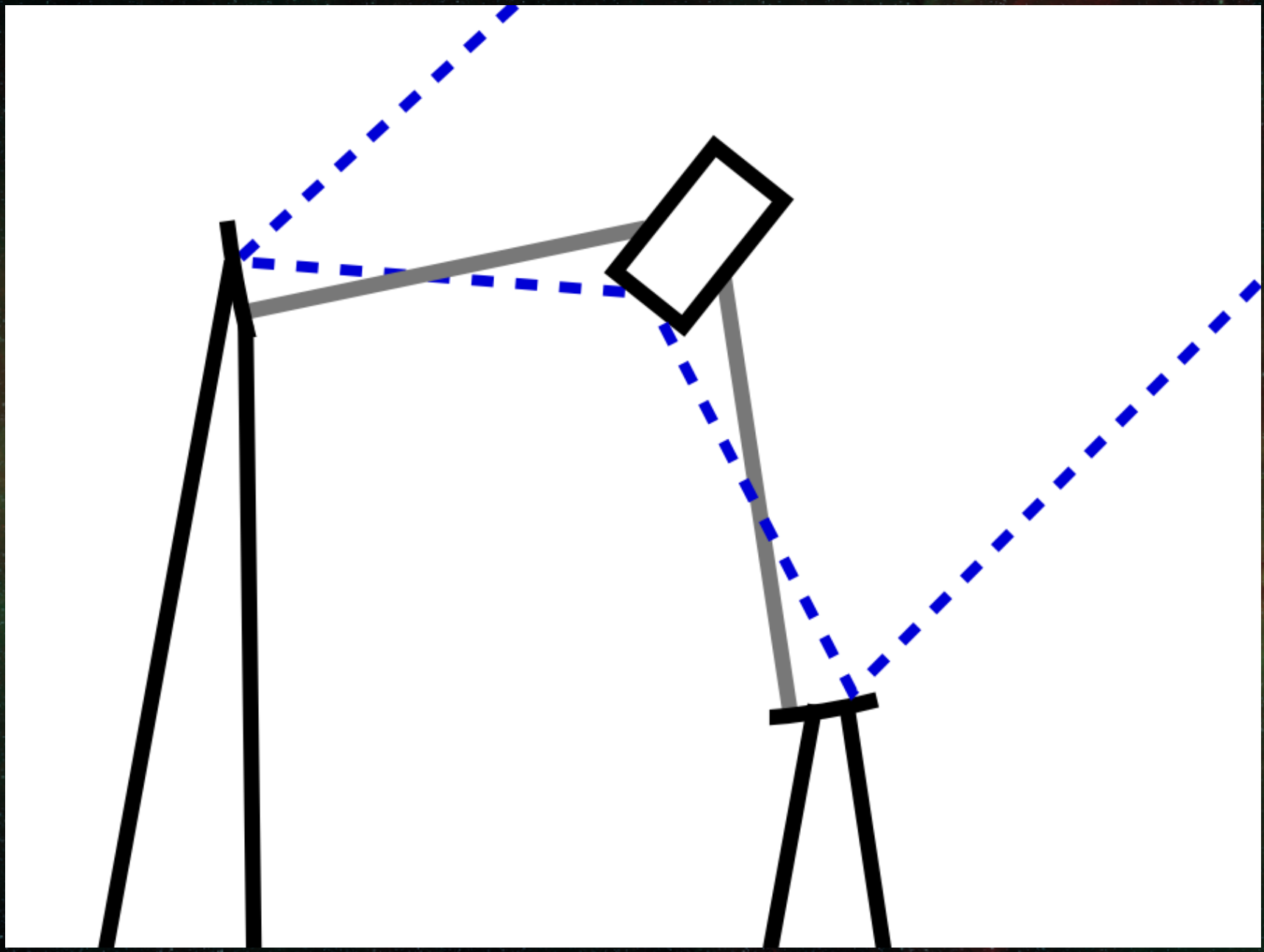
Magnus Waller




$$\theta \simeq \frac{\lambda}{D}$$







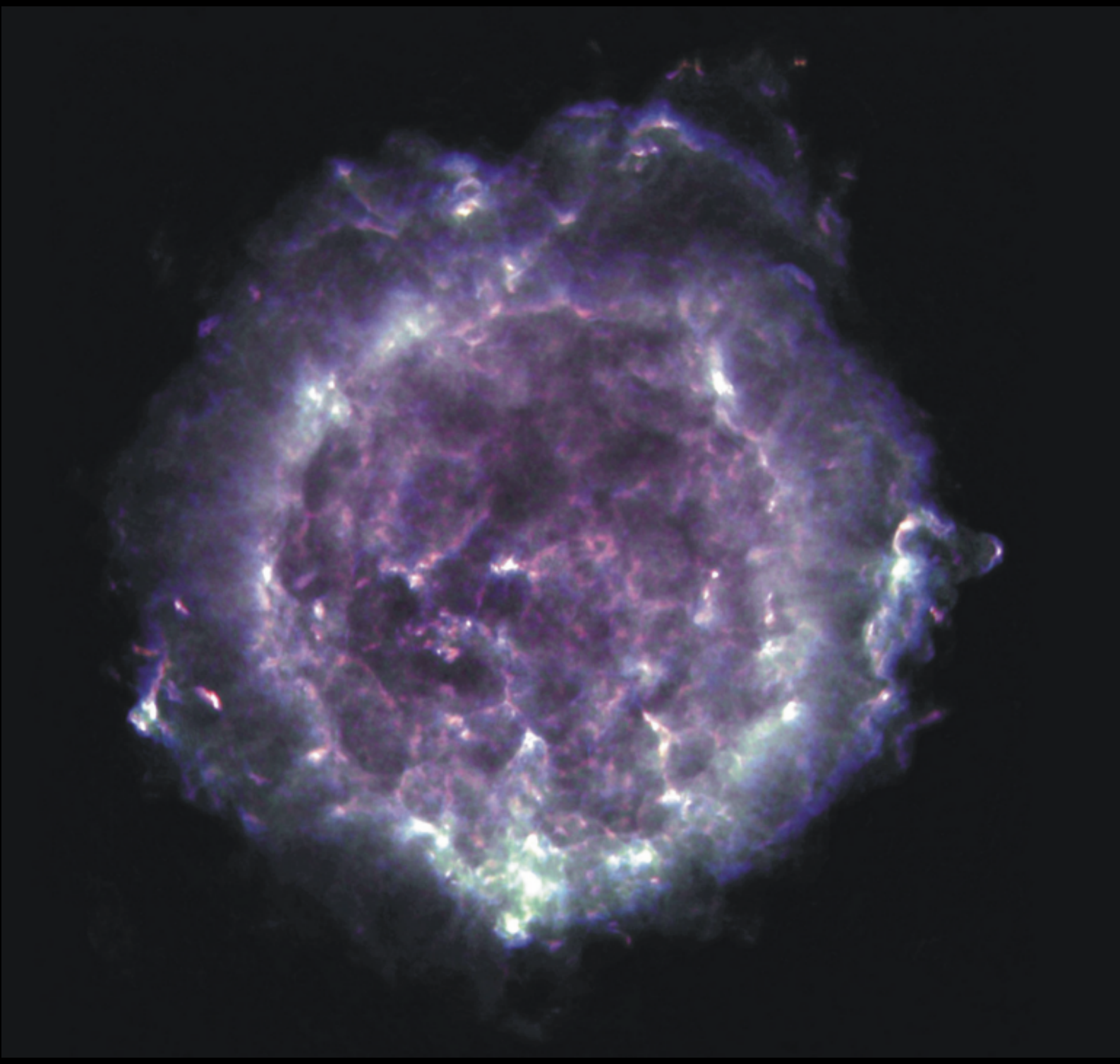


Image courtesy of NRAO/AUI

$$\hat{f}(u,v) = \int\int f(x,y) e^{-2\pi i(ux+vy)} \mathrm{d}x \mathrm{d}y$$

Image courtesy of NRAO/AUI

Image courtesy of NRAO/AUI

Image courtesy of NRAO/AUI

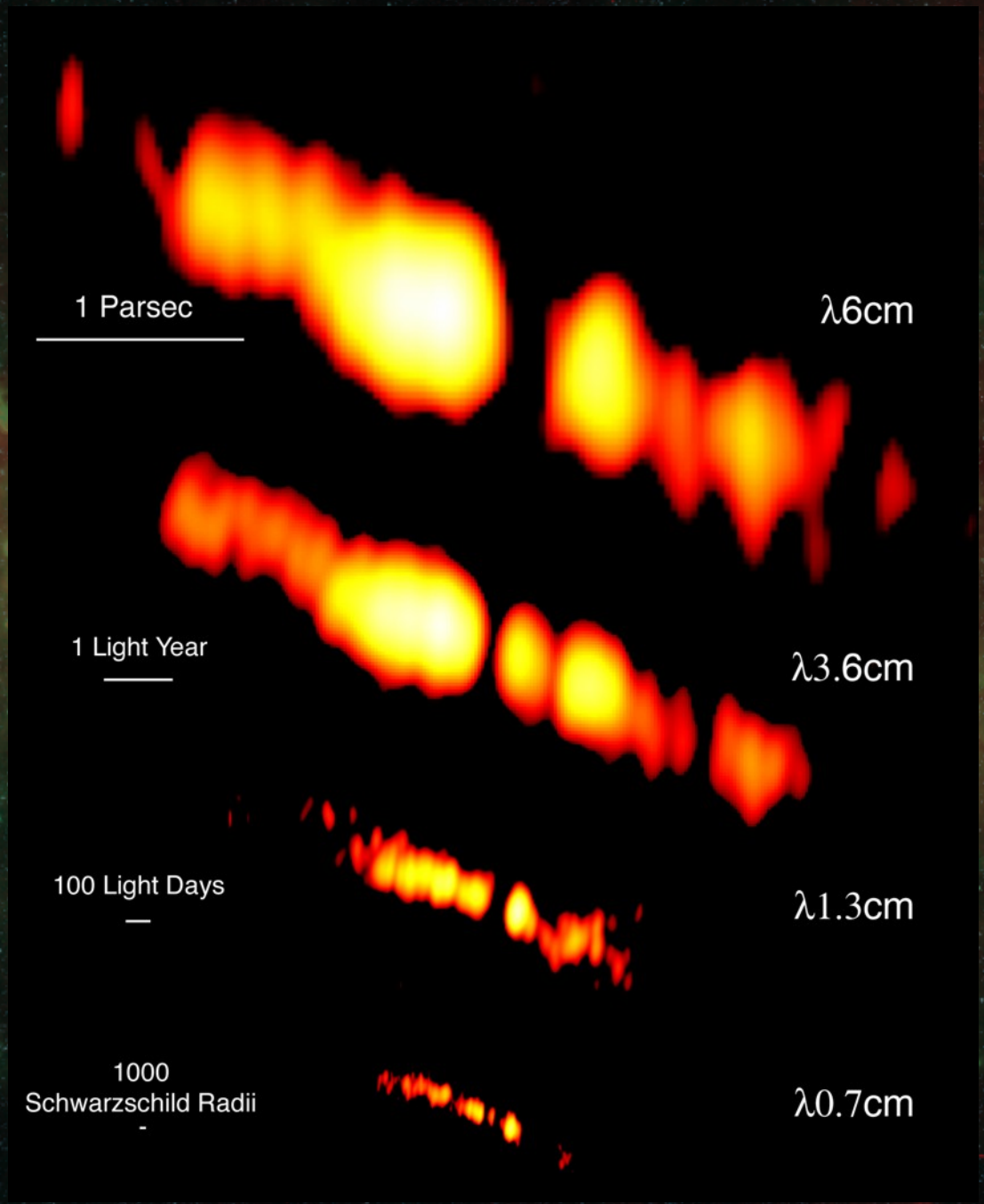
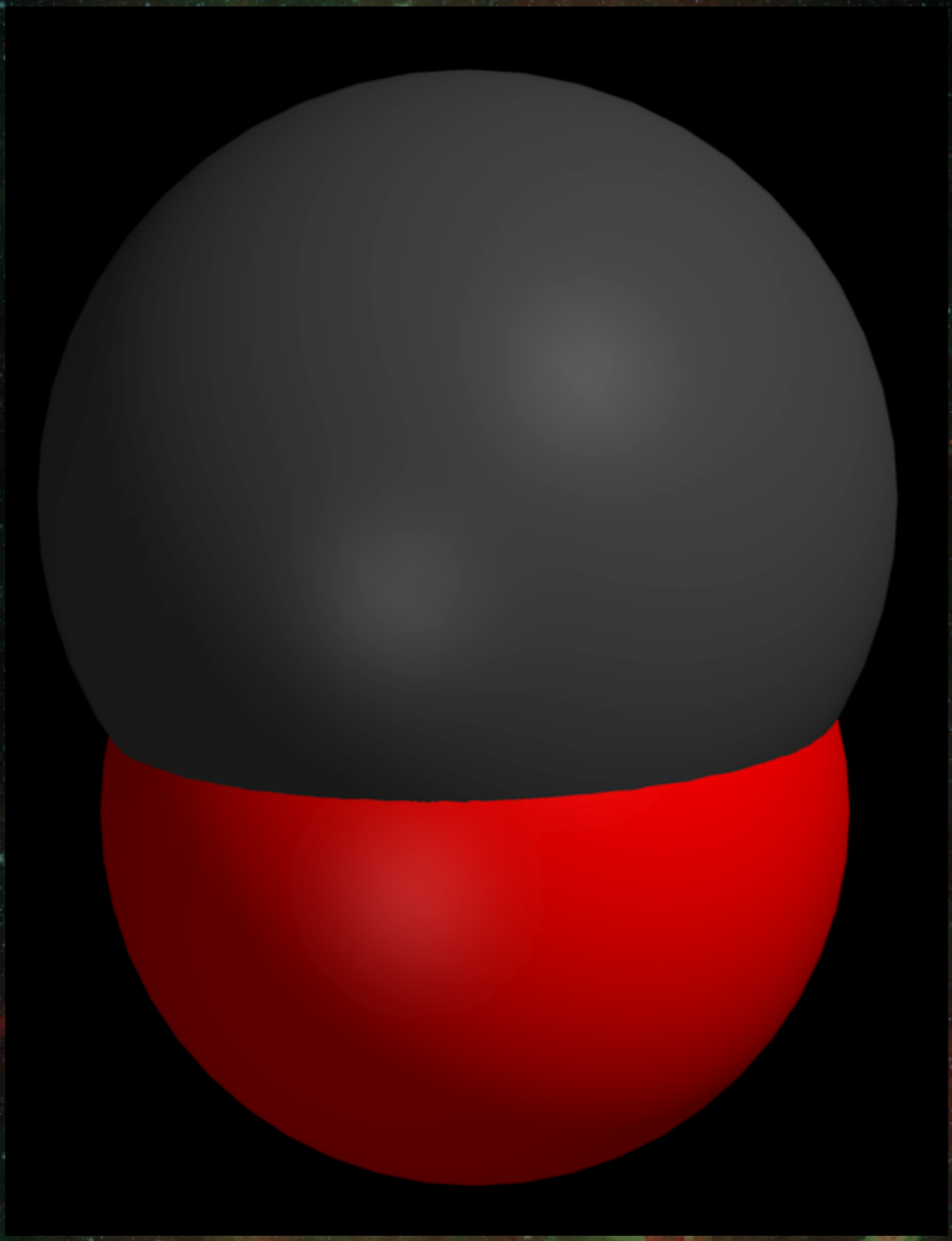


Image courtesy of NRAO/AUI and M. Kadler, NASA/GSFC; E. Ros, MPIfR

V. Modern and Future Radio Telescopes



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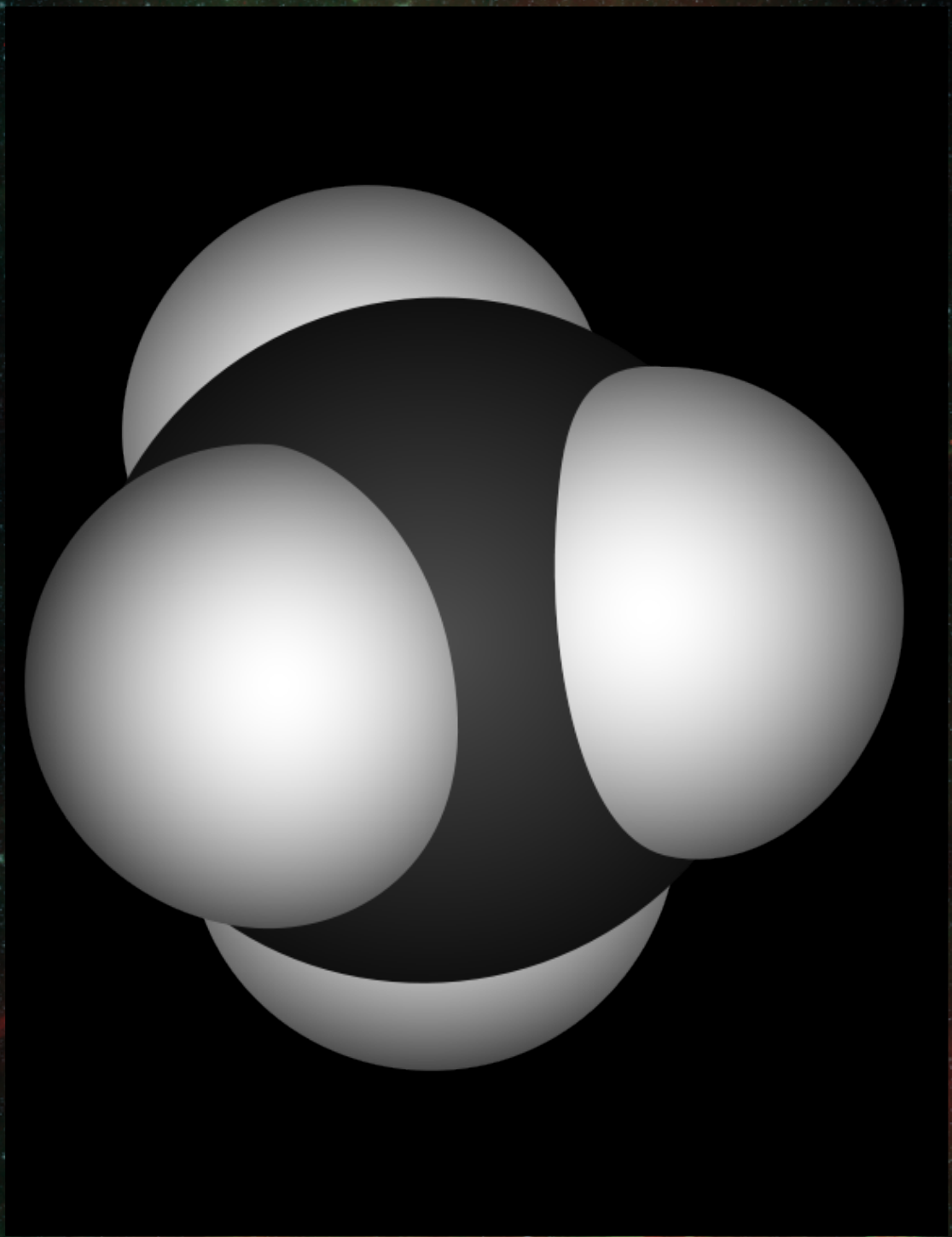

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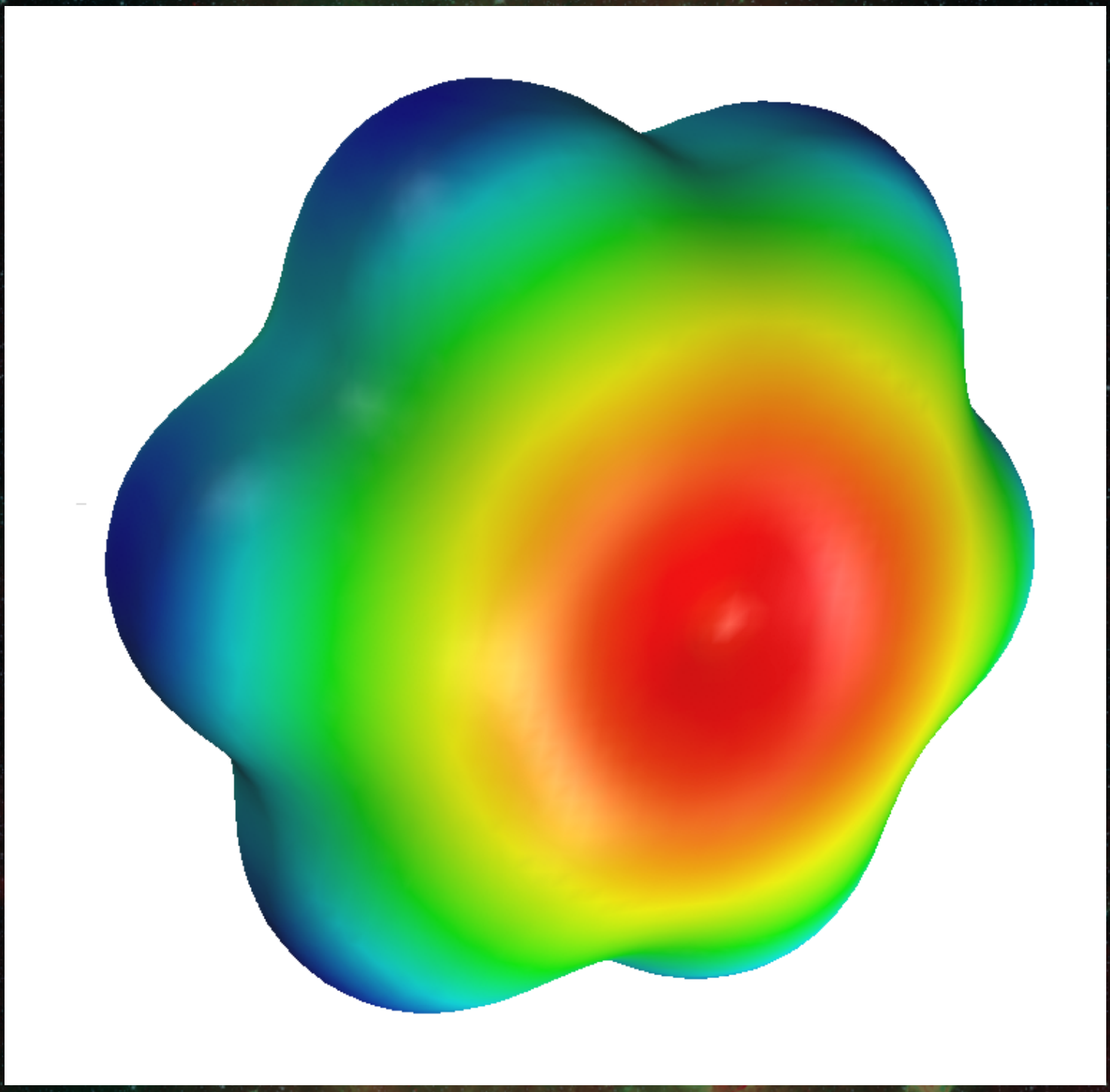

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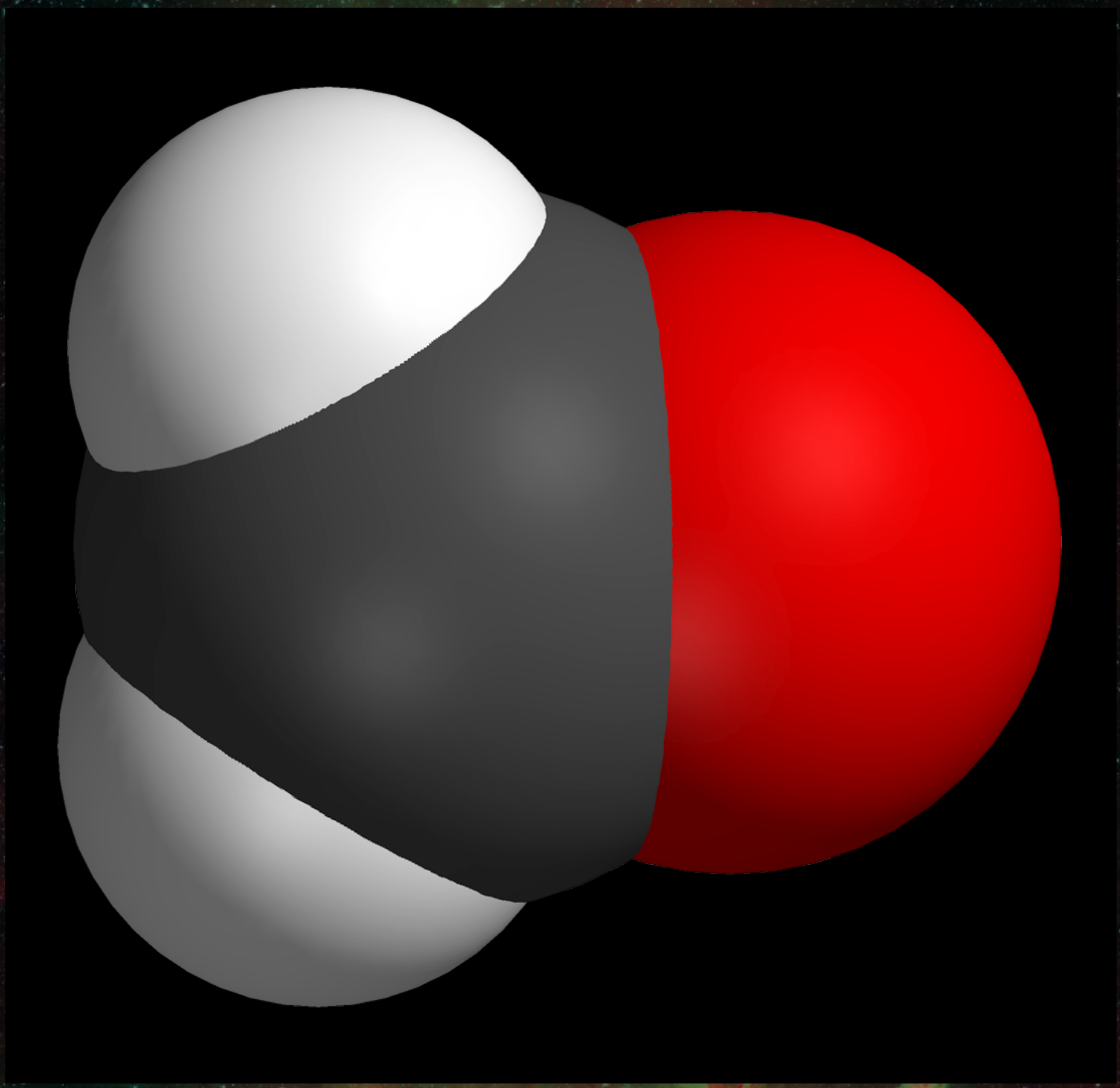

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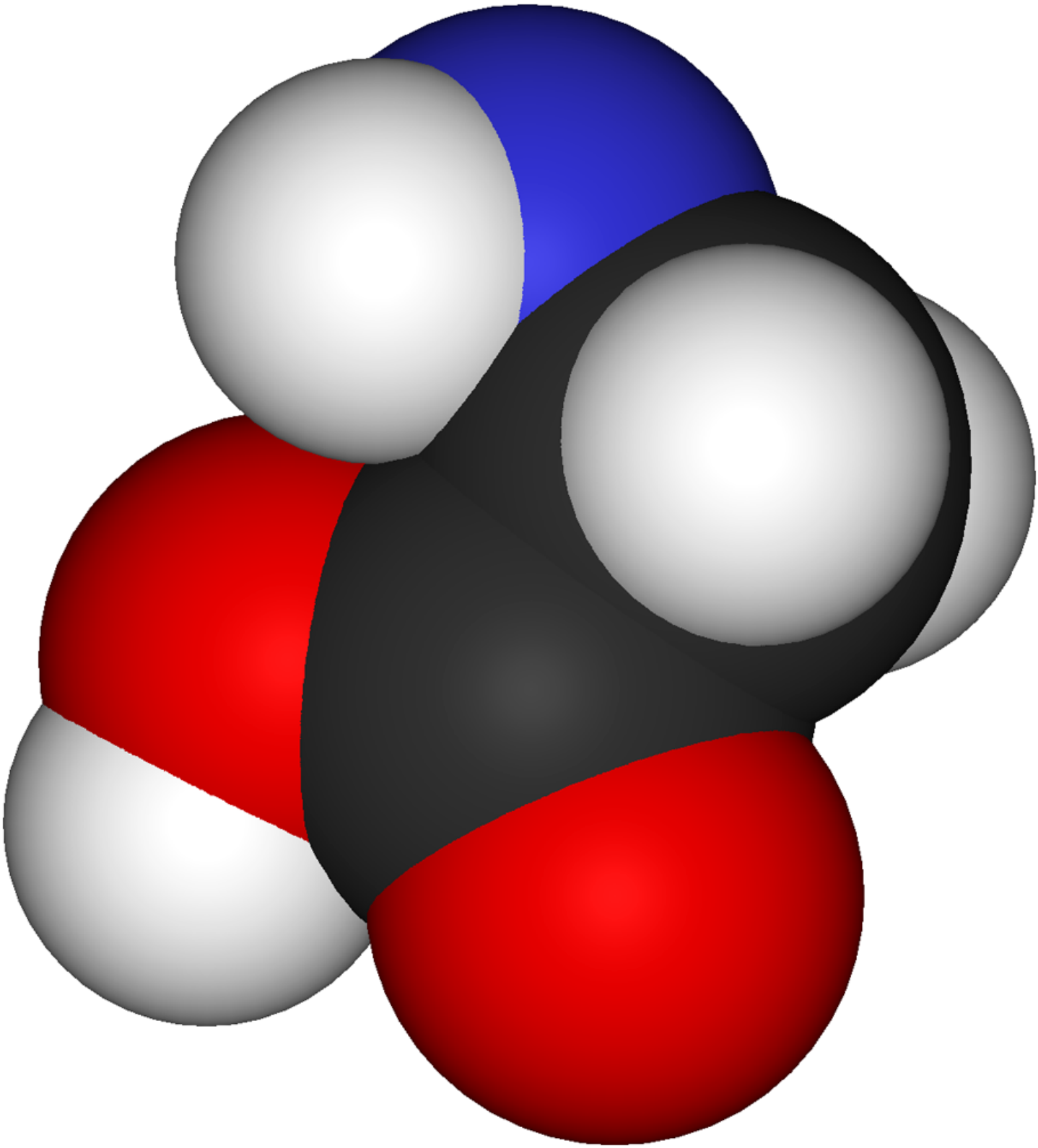

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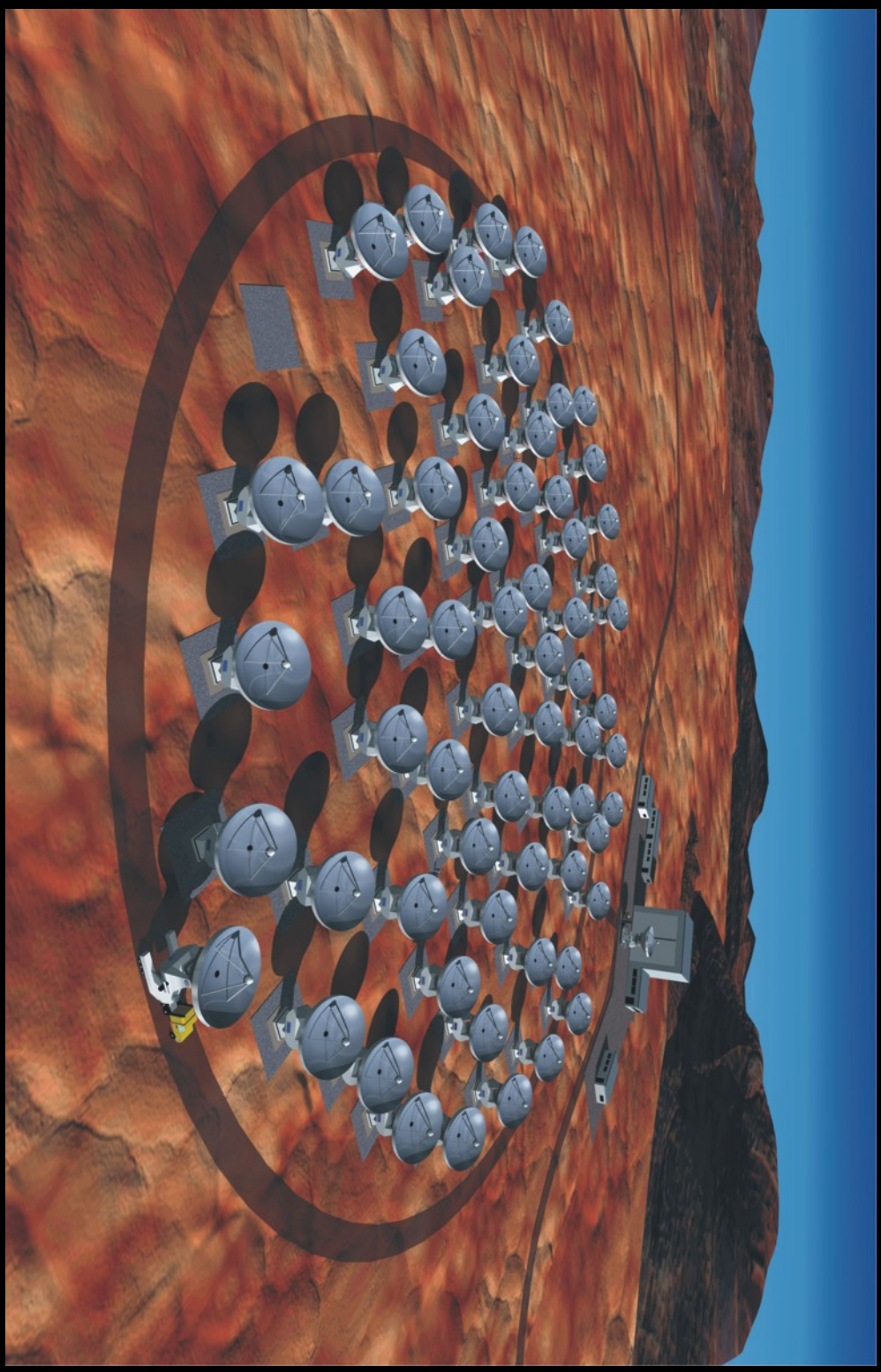
Erin, PAPER collaboration

LOFAR collaboration



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Bernard Fanaroff and TerraForma/SuW

Estate of G. Reber