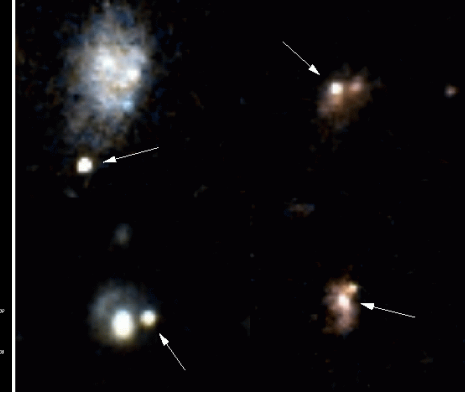
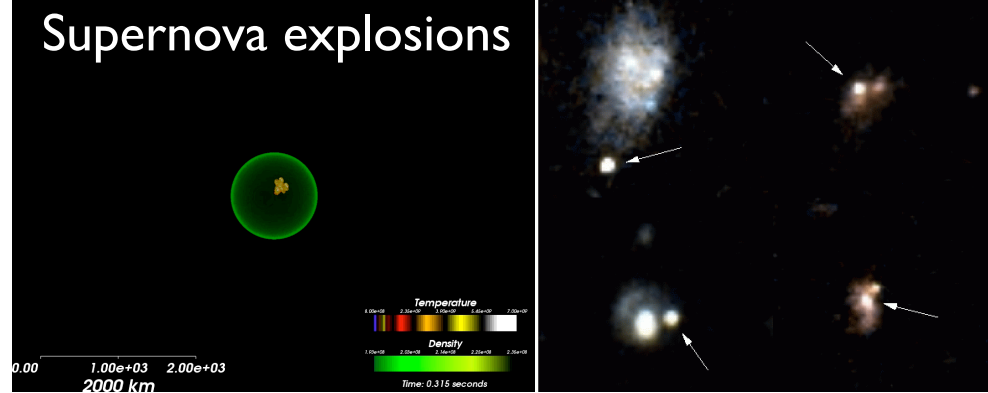
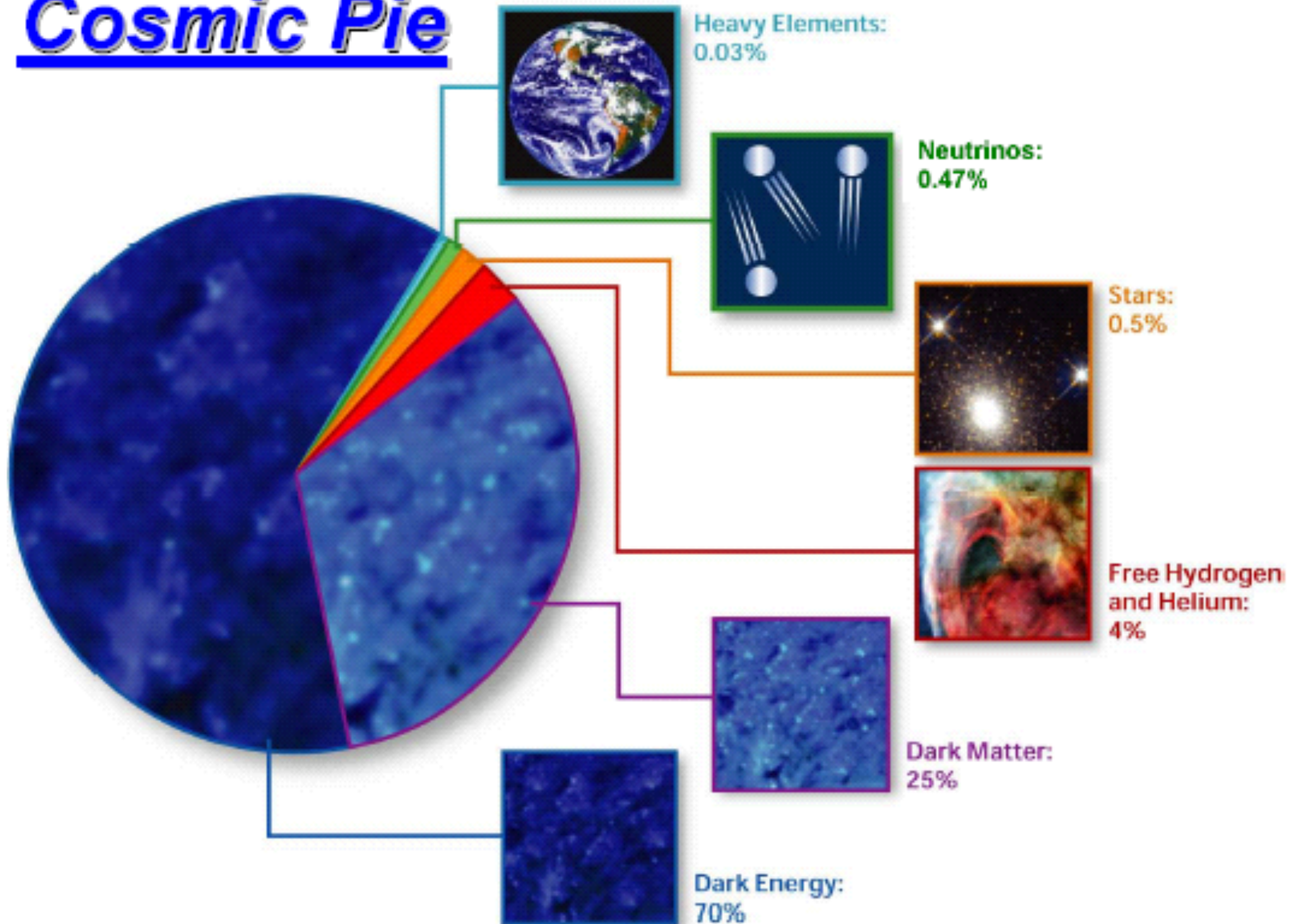
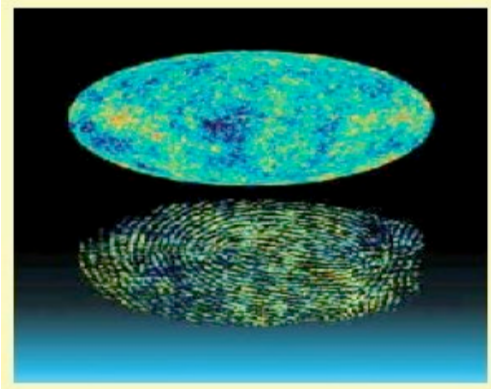


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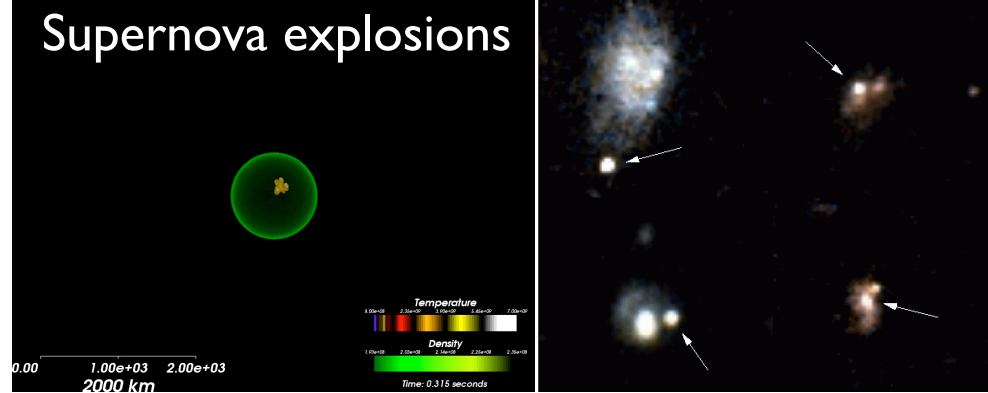


Cosmic Pie

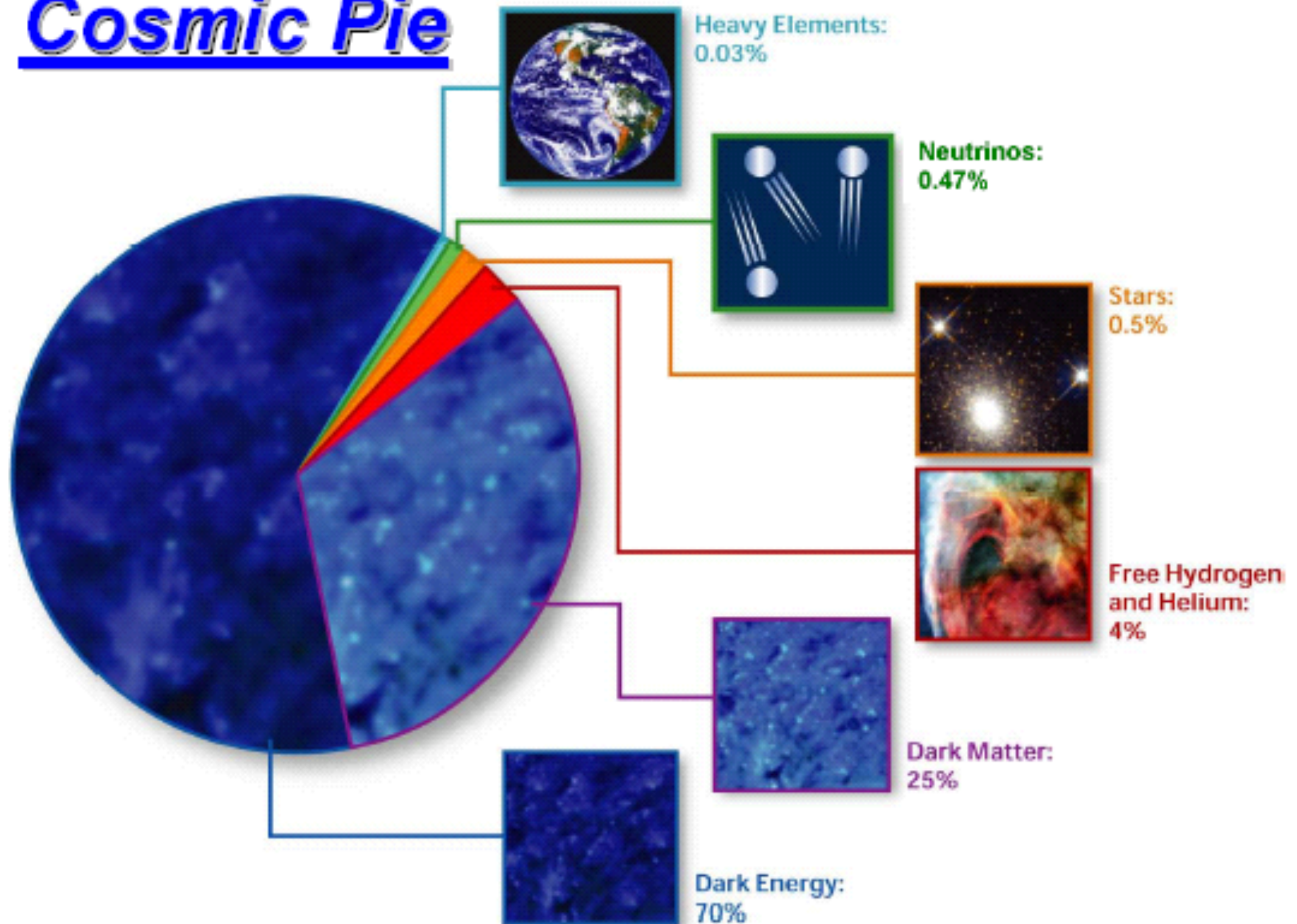




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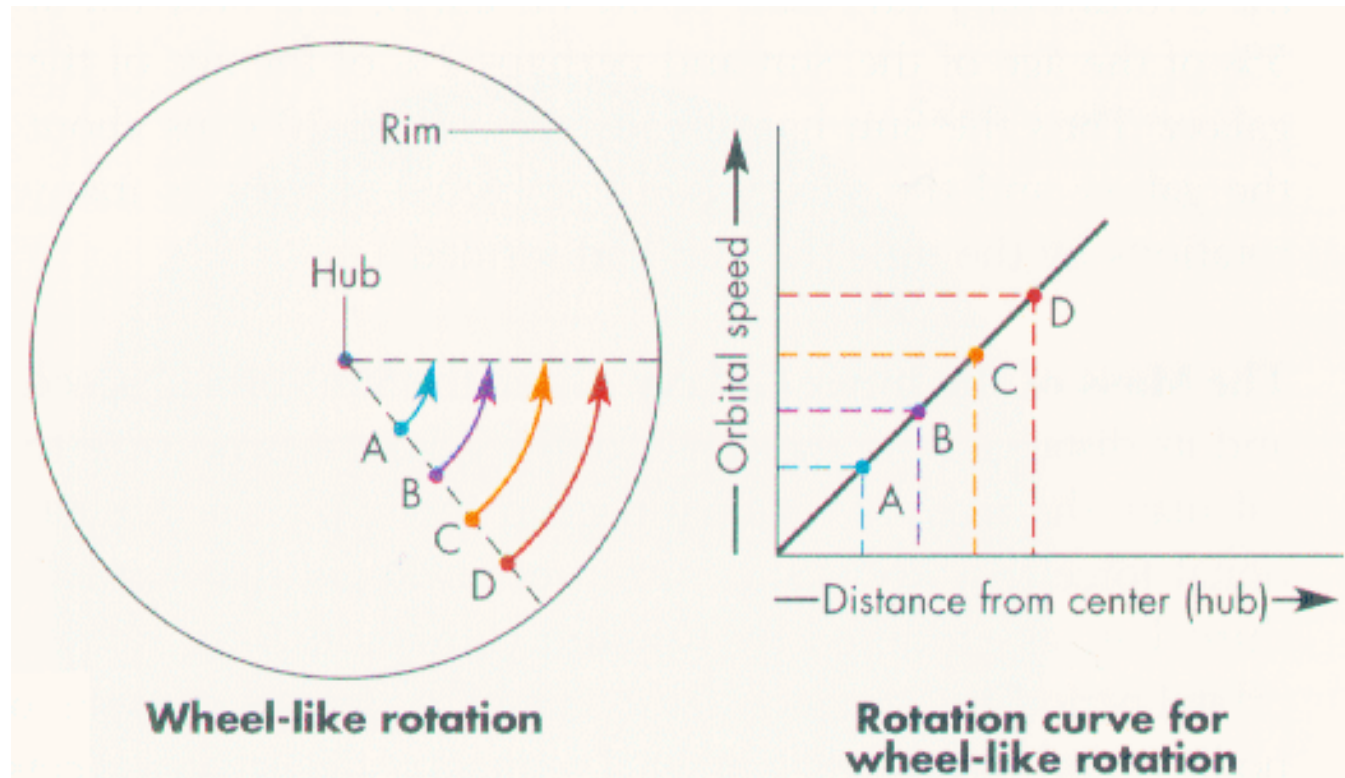


Cosmic Pie

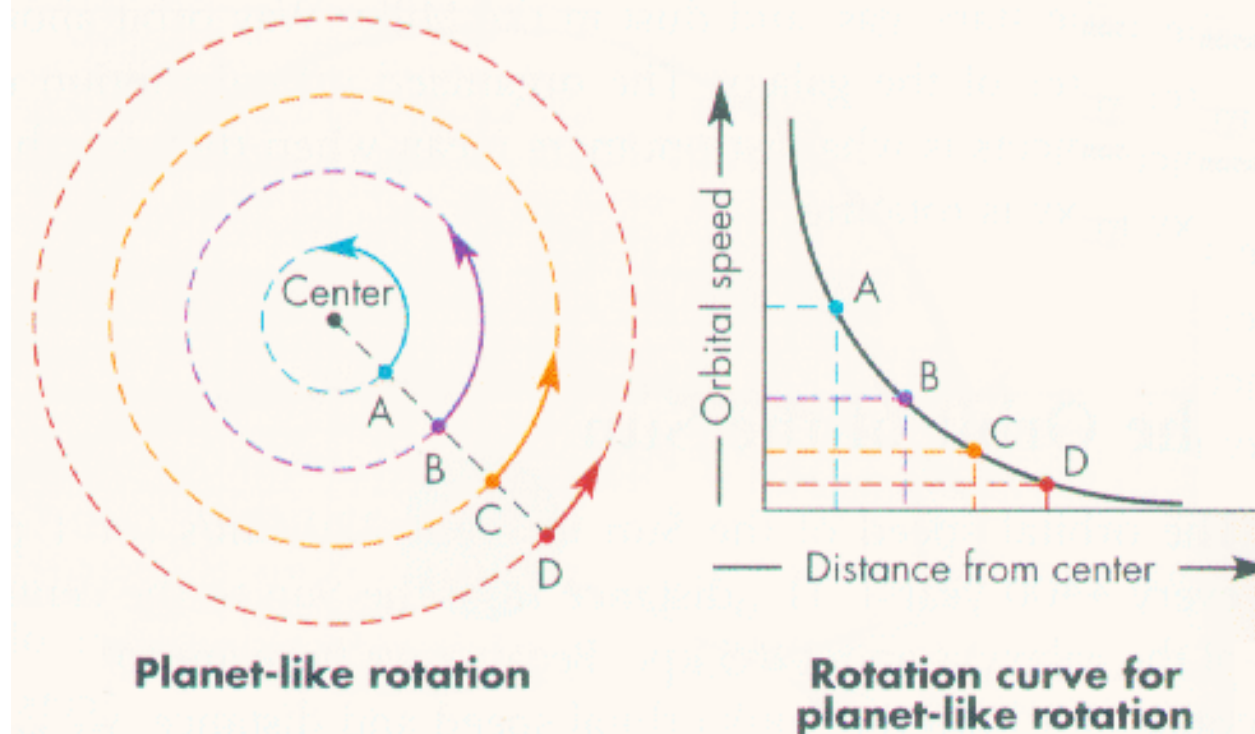


What other evidence of the existence of Dark Matter?

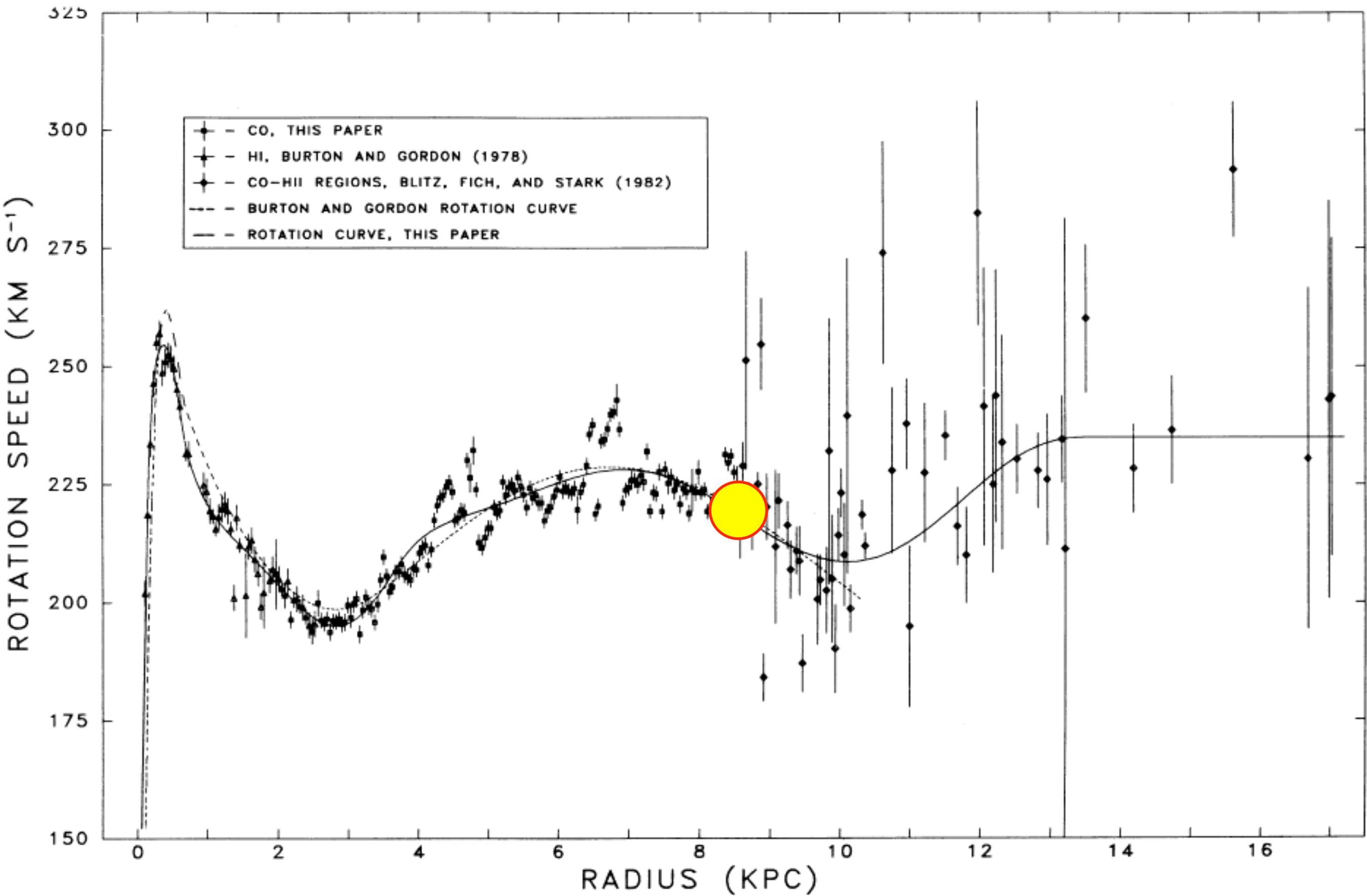
Rigid disk
(merry-go-round)

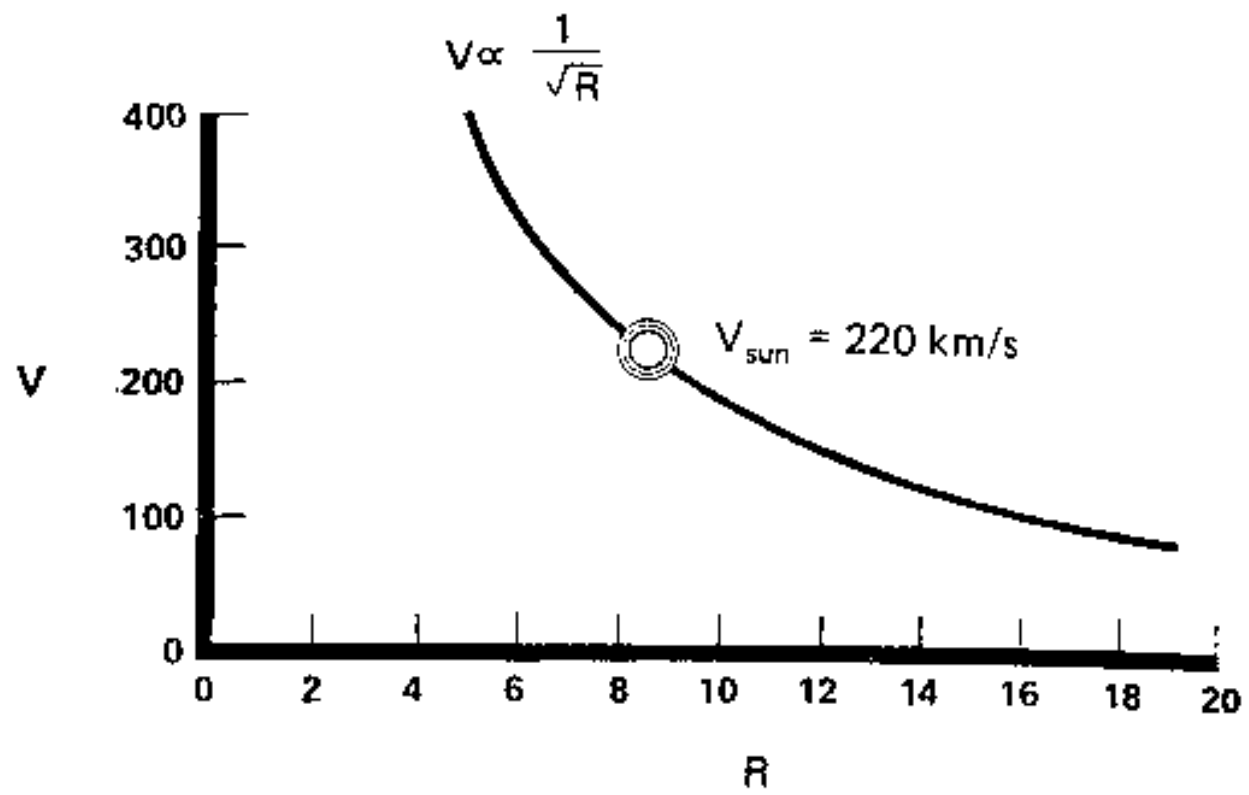


Solar system

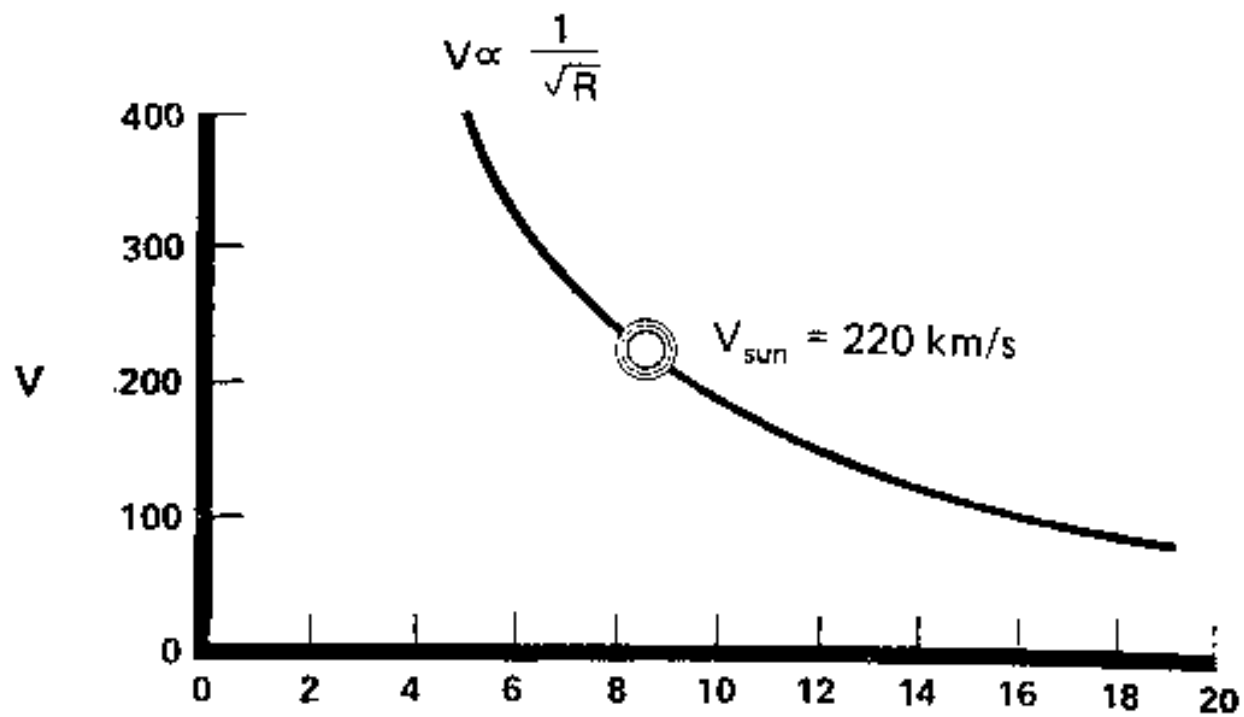


Milky Way rotation curve

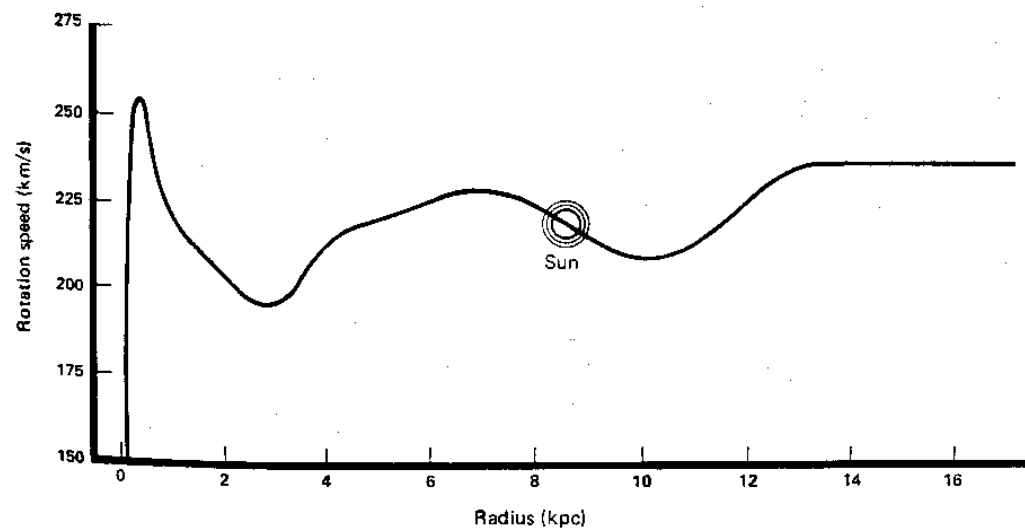




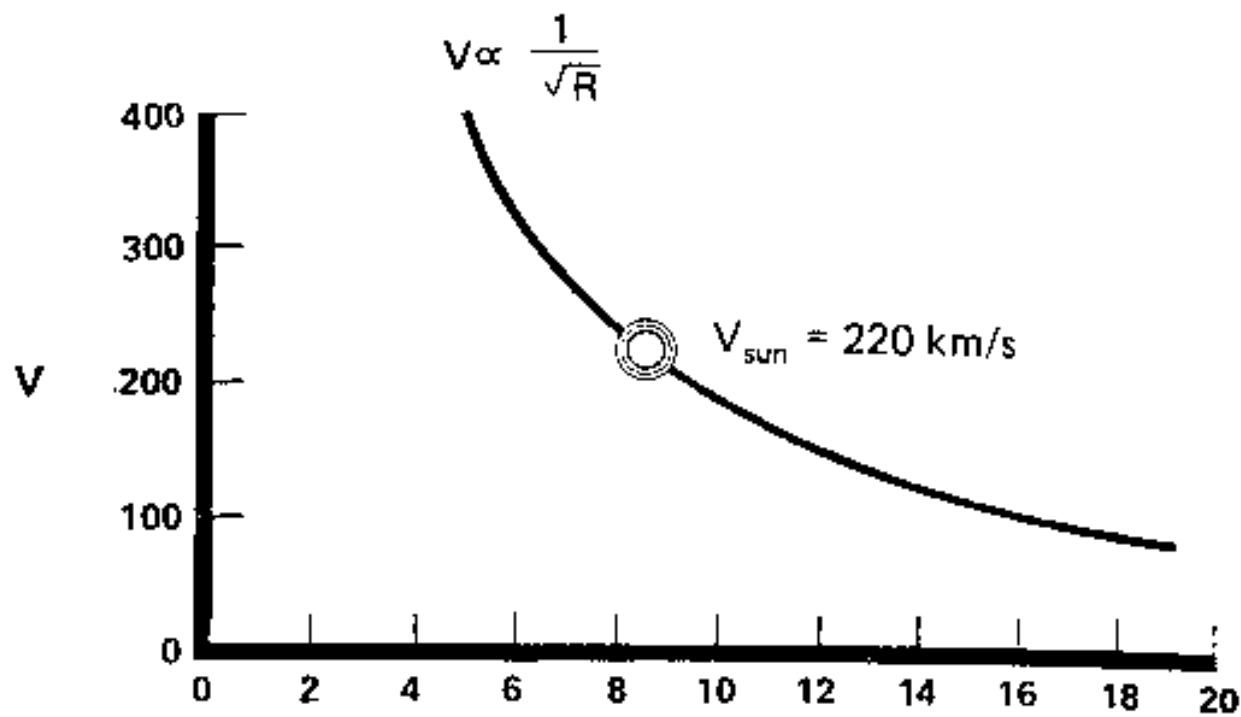
Rotation curve of a system with most of the mass concentrated in the center (e.g., solar system).



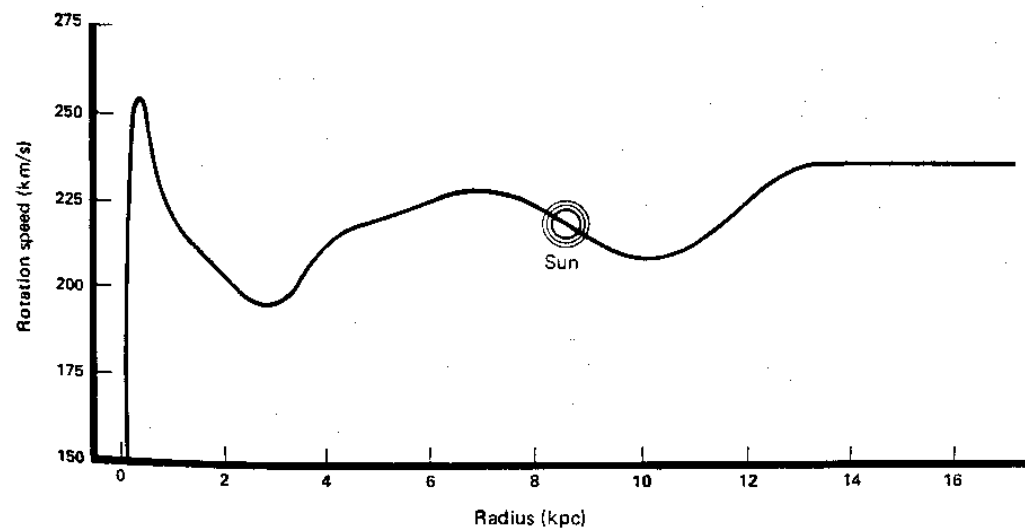
Rotation curve of a system with most of the mass concentrated in the center (e.g., solar system).



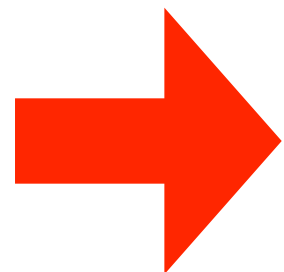
Observed rotation curve of the Milky Way, being constant (flat rotation curve) at large distances from center.



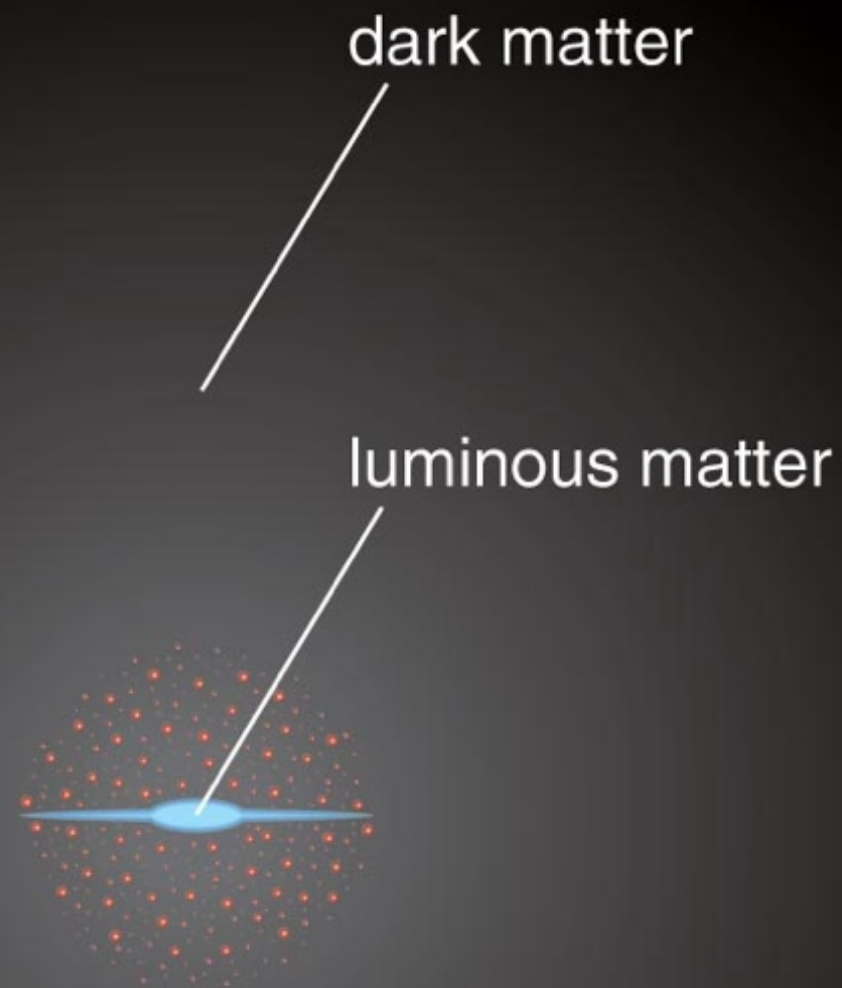
Rotation curve of a system with most of the mass concentrated in the center (e.g., solar system).



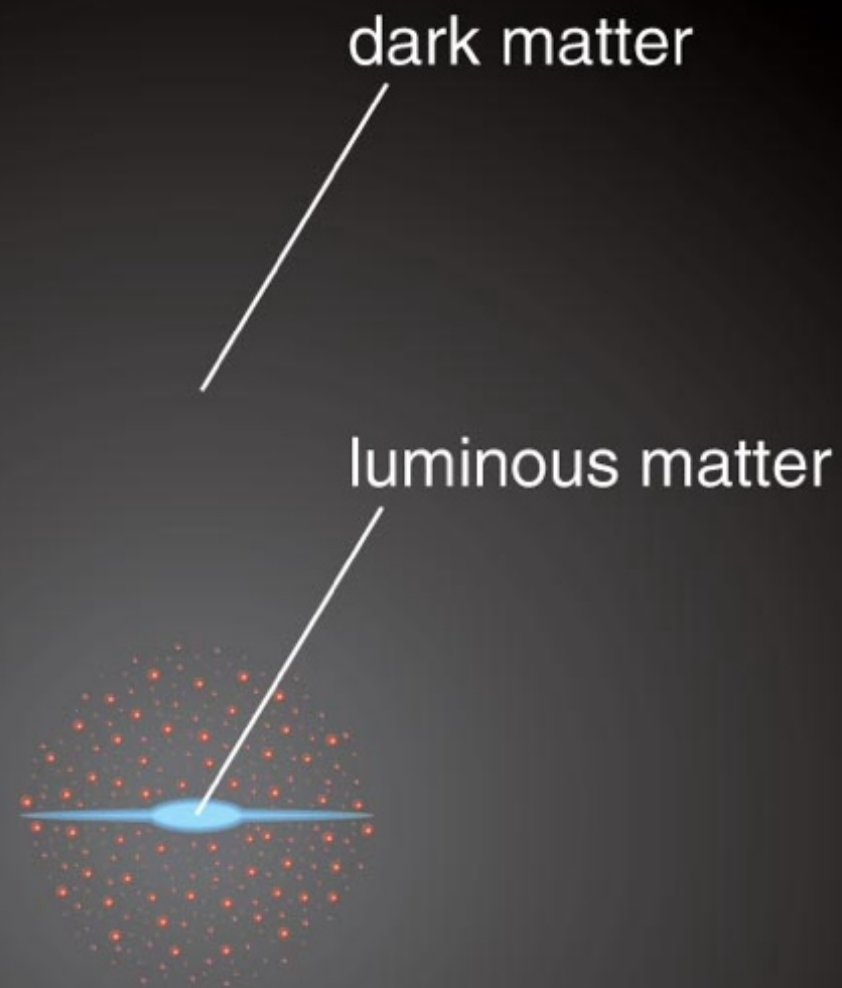
Observed rotation curve of the Milky Way, being constant (flat rotation curve) at large distances from center.



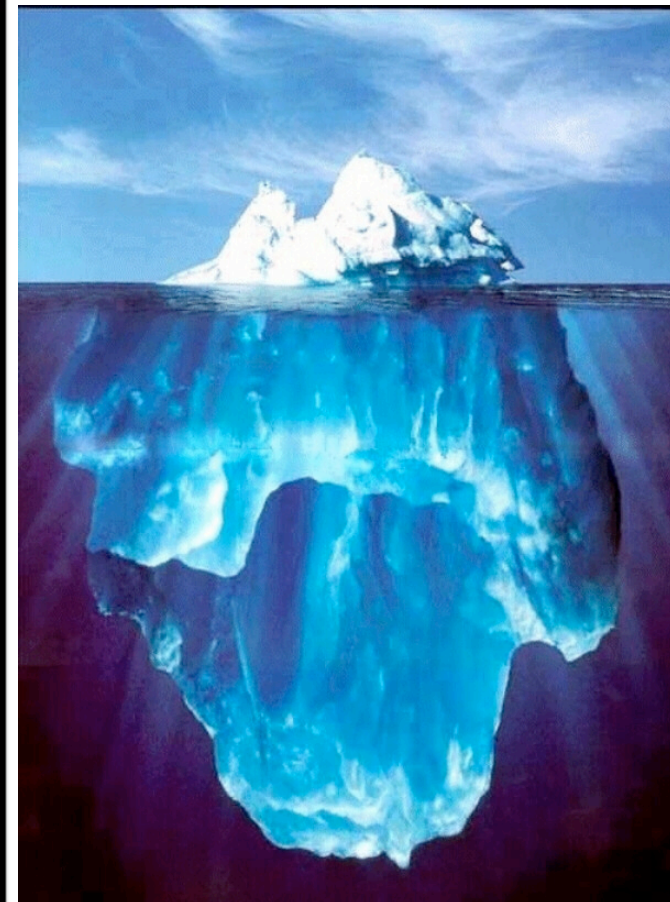
DARK MATTER: most of the matter of the Milky Way is far away from the center, distributed throughout the halo where there are a few stars and no gas and dust.

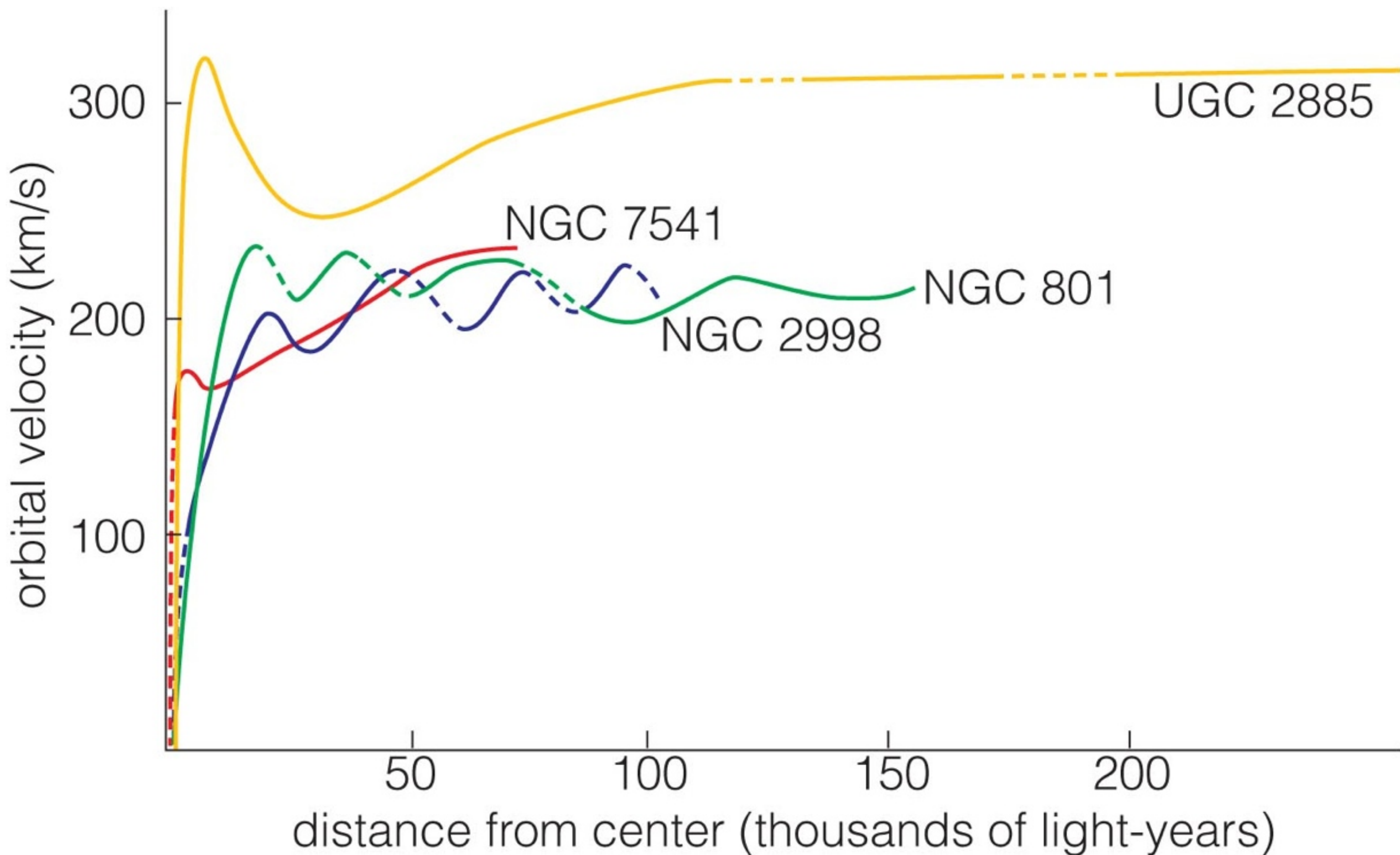


★ The visible portion of a galaxy lies deep in the heart of a large halo of dark matter.



★ The visible portion of a galaxy lies deep in the heart of a large halo of dark matter.

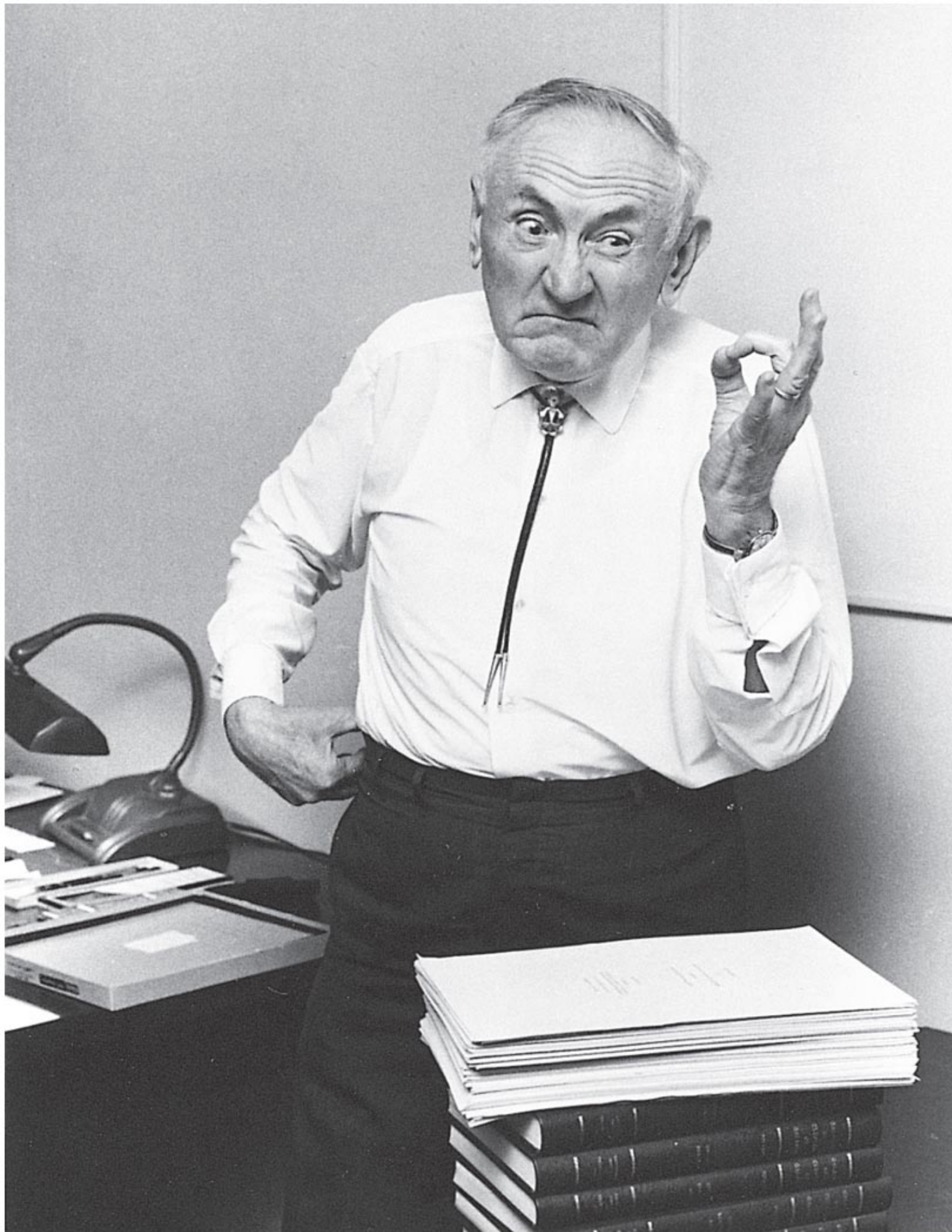




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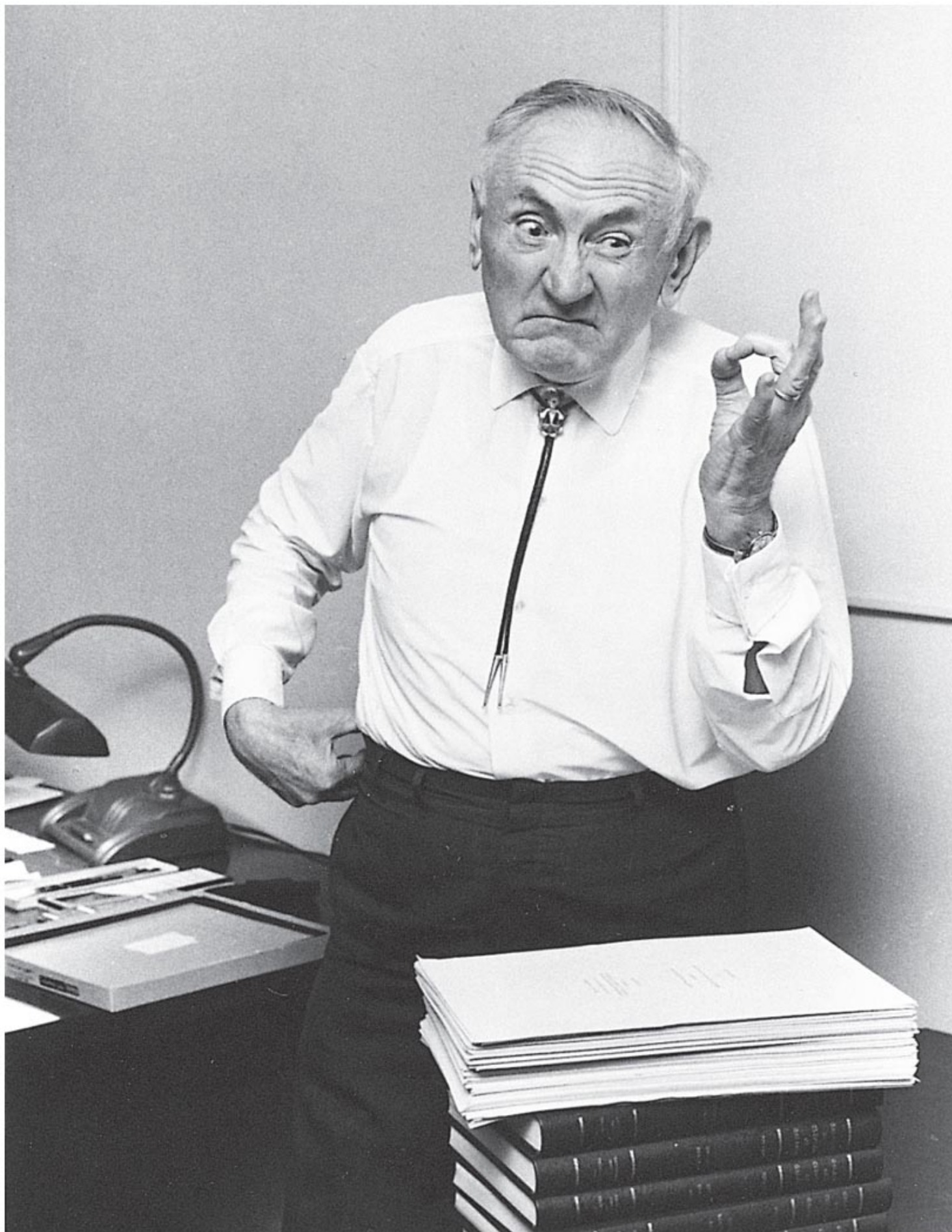
★ **Spiral galaxies** all tend to have flat rotation curves, indicating large amounts of dark matter (90% DM, 10% or less in stars).

Fritz Zwicky: 1898-1974



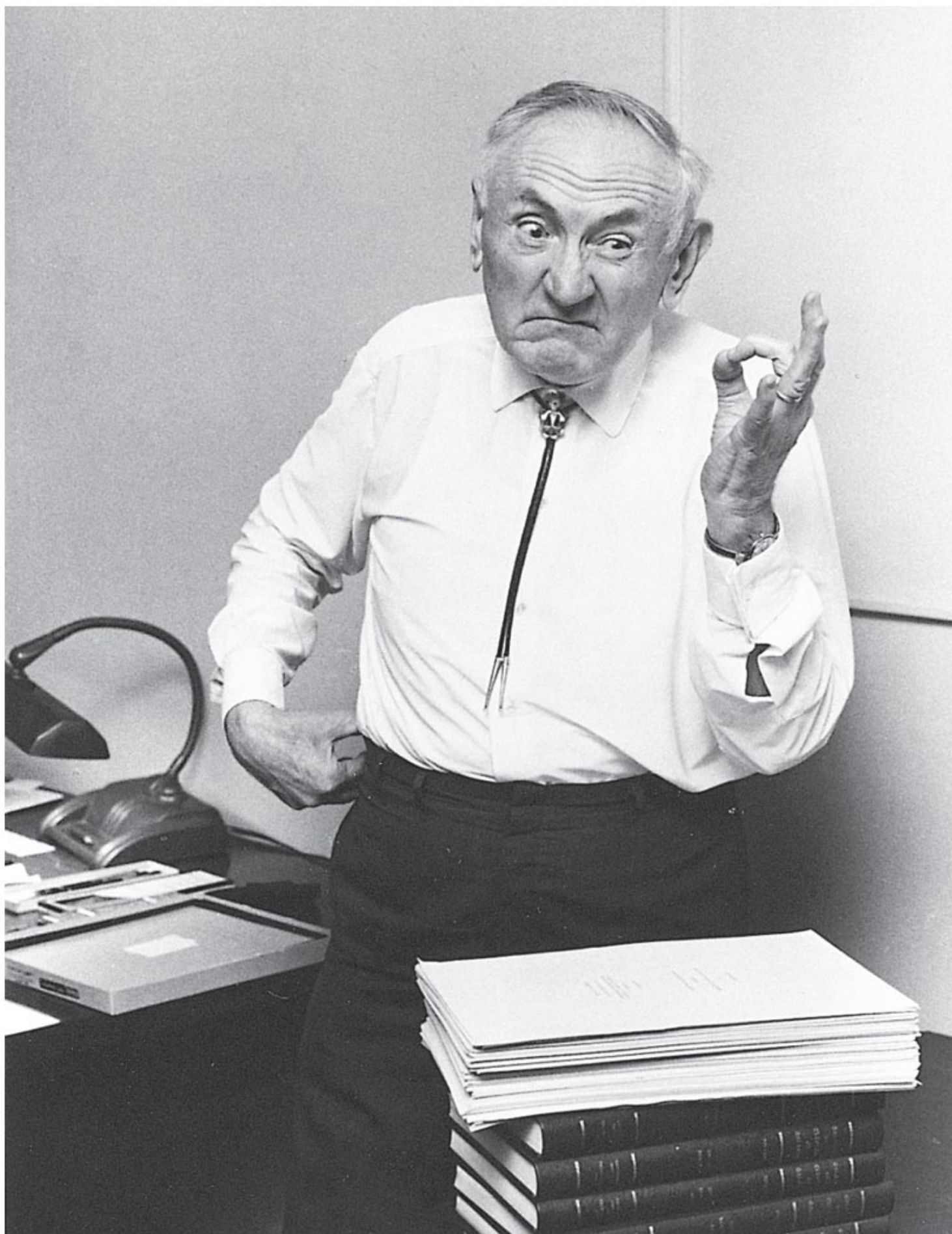
Fritz Zwicky: 1898-1974

“To base the un-explainability and the immense wonder of nature onto another miracle God is unnecessary and not acceptable for any serious thinker” [1971]



Fritz Zwicky: 1898-1974

“To base the un-explainability and the immense wonder of nature onto another miracle God is unnecessary and not acceptable for any serious thinker” [1971]



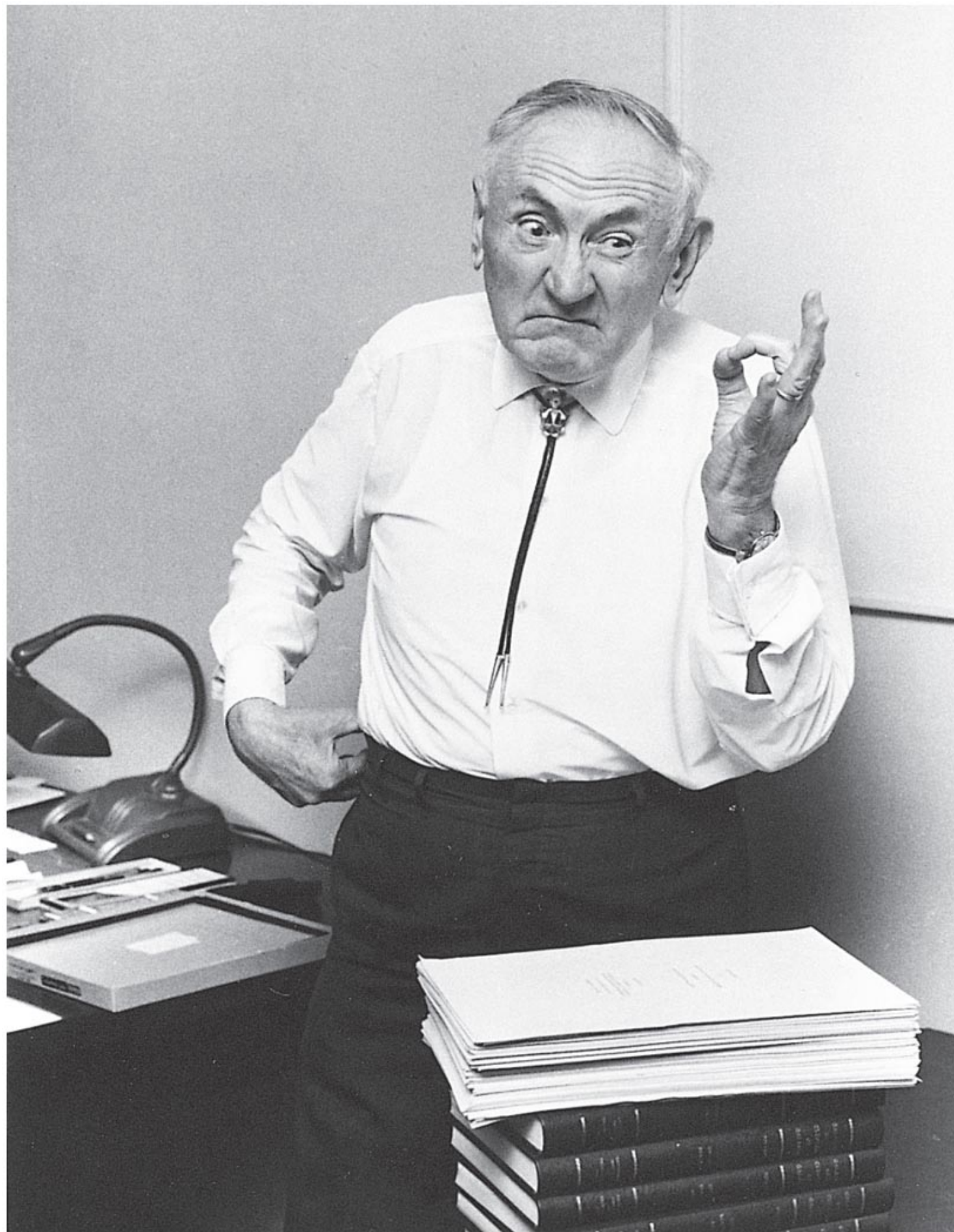
Consider a spherical cow
of radius R ...



Fritz Zwicky: 1898-1974

“To base the un-explainability and the immense wonder of nature onto another miracle God is unnecessary and not acceptable for any serious thinker” [1971]

“Astronomers are spherical bastards, because they are bastards when looked at from any side.”



Vera Rubin: 1928-

