Bohr and Wheeler's Model of Fission

The 1939 Paper

By 1939, fission had become experimentally established. However, a theoretical model of what was happening to the nucleus was lacking. Neils Bohr and John A. Wheeler, did the simplest model they could come up with. They modeled the nucleus as a charged droplet, paying no attention to quantum mechanics, or what the drop was made of, except that it had a certain amount of charge and a certain volume. Here is their abstract:

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The Mechanism of Nuclear Fission

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On the basis of the liquid drop model of atomic nuclei, an account is given of the mechanism of nuclear fission. In particular, conclusions are drawn regarding the variation from nucleus to nucleus of the critical energy required for fission, and regarding the dependence of fission cross section for a given nucleus on energy of the exciting agency. A detailed discussion of the observations is presented on the basis of the theoretical considerations. Theory and experiment fit together in a reasonable way to give a satisfactory picture of nuclear fission.

The full PDF is online at:

Amazingly, despite the fact that people were realizing that fission was potentially a weapon, this paper was published openly on September 1, 1939, at the same time as Hitler invaded Poland.

Slightly less than five years later on July 16, 1944, the first fission explosion called Trinity was done Alamagordo, New Mexico.

For more information, consult https://www.afnwc.af.mil/About-Us/History/Trinity-Nuclear-Test/.

A 2-D Model

adafsad

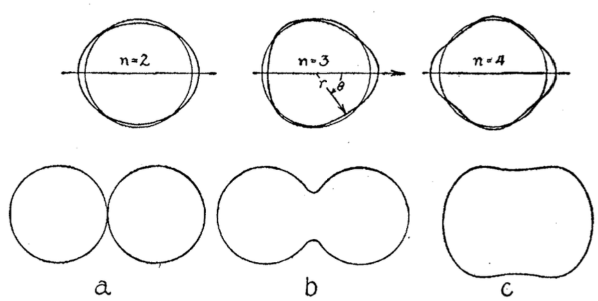
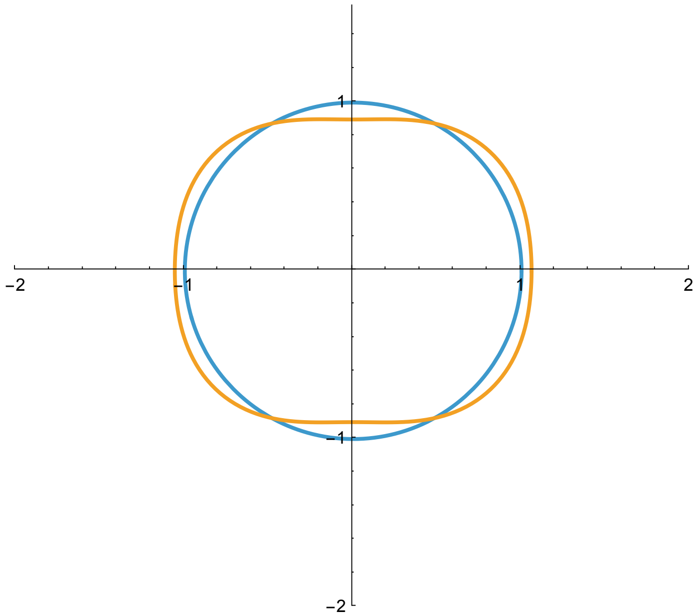


FIG. 2. Small deformations of a liquid drop of the type $\delta r(\theta)=\alpha_n P_n(\cos\,\theta)$ (upper portion of the figure) lead to characteristic oscillations of the fluid about the spherical form of stable equilibrium, even when the fluid has a uniform electrical charge. If the charge reaches the critical value $(10\times\text{surface tension}\times\text{volume})^{\frac{1}{2}}$, however, the spherical form becomes unstable with respect to even infinitesimal deformations of the type $n=2$. For a slightly smaller charge, on the other hand, a finite deformation (c) will be required to lead to a configuration of *unstable equilibrium*, and with smaller and smaller charge densities the critical form gradually goes over (c, b, a) into that of two uncharged spheres an infinitesimal distance from each other (a).

In[∘]:=
```
Animate[Module[{r = 1, alpha2 = 0.5, alpha4 = 0.15},
  PolarPlot[{r, r (1 + alpha2 LegendreP[2, Cos[θ]] Sin[2 Pi t] -
       alpha4 LegendreP[4, Cos[θ]] Sin[4 Pi t])},
   {θ, 0, 2 Pi}, PlotRange → {{-2, 2}, {-2, 2}}]], {t, 0, 1}]
```

Out[∘]=

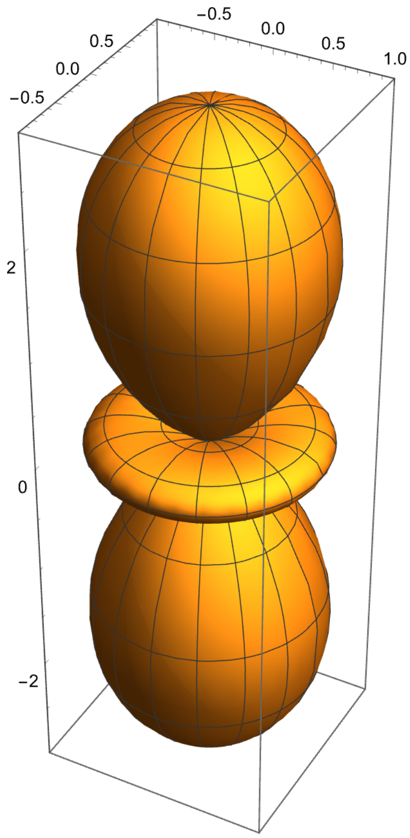


A 3-D Model

Now we will jack up the realisticness of the model, by making it a three-dimensional drop, using SphericalPlot3D

In[46]:=
```
SphericalPlot3D[1 + 2 Cos[2 θ], {θ, 0, Pi}, {ϕ, 0, 2 Pi}]
```

Out[46]=



The Model Results

Comparison with Experiment