Dark matter in the Milky Way as the F-type of vacuum polarization

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Problems of general relativity: existence of black holes and vacuum energy problem.

Solution: restrict class of possible metrics by conformally-unimodular metrics

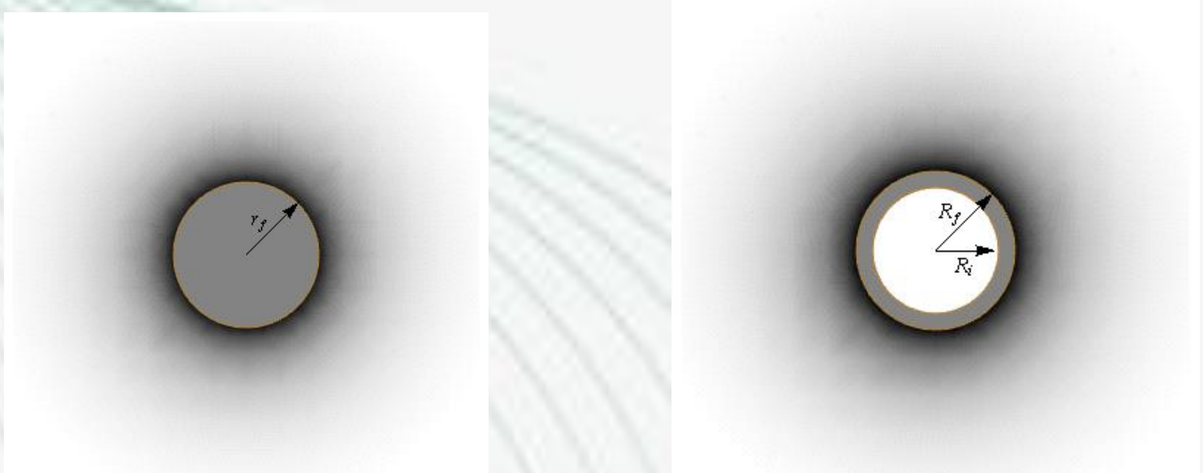
$$ds^2 = g_{\mu\nu}dx^\mu dx^\nu = a^2\left(1-\partial_m \Upsilon^m\right)^2 d\eta^2 - \gamma_{ij}(dx^i + N^i d\eta)(dx^j + N^j d\eta), \qquad a = (\det \gamma_{ij})^{1/6}$$

That is, we restrict lapse function as $N = a\left(1-\partial_m \Upsilon^m\right)$, **where** Υ **is some 3-vector**

Spherically-symmetric case of conformally-unimodular metric

$$ds^2 = a^2(d\eta^2 - \tilde{\gamma}_{ij}dx^i dx^j) = e^{2\alpha}\left(d\eta^2 - e^{-2\lambda}(d\mathbf{x})^2 - (e^{4\lambda} - e^{-2\lambda})(\mathbf{x}d\mathbf{x})^2/r^2\right),$$

Black holes do not exist. Eicheons instead of black holes.



Nonsingular eicheon

In the Schwarzschild type metric eicheon looks like a hollow sphere

Vacuum polarization by eicheon

Perturbations of conformally-unimodular metric

$$ds^2 = (1+\Phi(\eta,\mathbf{x}))^2\left(d\eta^2 - \left(\left(1+\frac{1}{3}\sum_{m=1}^{3}\partial_m^2 F(\eta,\mathbf{x})\right)\delta_{ij} - \partial_i\partial_j F(\eta,\mathbf{x})\right)dx^i dx^j\right)$$

Considering vacuum polarization in the eikonal approximation gives two types of vacuum polarization having the equations of states:

Φ **-type** $\quad \Pi_\Phi(\eta,\mathbf{x}) = \frac{1}{3}\wp_\Phi(\eta,\mathbf{x}) - M_p^2(\Phi'' - \Delta\Phi).$

F **-type** $\quad \Pi_F(\eta,\mathbf{x}) = \frac{1}{3}\wp_F(\eta,\mathbf{x}),$ has radiation equation of state, i.e. it is dark radiation

Spherically symmetric solution: eicheon + "dark radiation": rotational curve of Milky Way,

observations with error bars are taken from Sofue, Y. *Publ. Astron. Soc. Jpn.* 2013, *65*, 118