

Re: Singularities

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Ramkins <ramkinkar@gmail.com> wrote:

- > *Cosmological solutions are there that had singularities in their past.*
 - > *FRW universes with dust or radiation have a singularity in their past.*
 - > *A solution like the closed de Sitter solution has no singularity.*
 - > *So a cosmological constant or a vacuum fluid can avoid such a*
 - > *singularity.*
- > *Generally, what are the necessary criteria for a past singularity?*

I don't think much is known about necessary criteria. Several sets of *sufficient* criteria are given by the Hawking–Penrose singularity theorems; generally these involve matter satisfying some positive energy condition plus a past trapped surface. De Sitter space avoids a singularity because a cosmological constant, considered as part of the stress–energy tensor, violates the positive energy requirements.

You can find details in Hawking and Ellis, *The large scale structure of space–time*, or in chapter 9 of Wald's textbook, *General Relativity*. (I imagine there are less technical sources as well, but don't know of any off hand. For FRW spaces, it's easier; there will be a past singularity if the density ρ is positive and the pressure p is non–negative.)

Steve Carlip