Dark matter
Particle Physics and Cosmology

LianTao Wang
University of Chicago

UCAS.
Introduction
Dark matter in the universe

We know dark matter is out there.
But we don’t know what it is.
Observational evidence of dark matter
More matter than light

Zwicky 1933
More matter than light

Dark matter in the satellites of the Milky Way

Rotational curve

M33

Vera Rubin
1970
Bullet cluster
Bullet cluster
Bullet cluster

dark matter
A consistent picture

Consistency of different cosmological measures of the matter density

The different measures of matter density from growth of clusters, fraction of gas in clusters, CMB, Supernova distances and Baryon acoustic oscillation all agree on a value for the matter density that is close to 25% of the critical density of the universe, which is about 6 times the density in baryons.
Basic facts about dark matter.
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- Very dark, charge \( < 10^{-3} \text{ e} \).
- Mass.
  - Seed structure: \( 1/m = \text{de Brogile wave length} < \text{size of sub-halo} \). \( m > 10^{-33} \text{ GeV} \)
  - Not too big to block light. \( m < 10^{47} \text{ GeV} \).
  - 80 order of magnitude allowed range.
Beyond the Standard Model

Stable SM particles can not be dark matter

Photon: massless
Neutrino: < 1 eV
Electron: charged
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Dark matter = new unknown particle!