ASTROPARTICLE PHYSICS IN 2042

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KICP visitor Oct. - Jan. 2015
UChicago postdoc 2009 - 2011
(almost) everything is connected to cosmic rays
current status and tools

neutrinos

gamma-rays

cosmic rays

acceleration

interactions on backgrounds @ source or during propagation

VERITAS
MAGIC
HESS-2
HAWC
Fermi

ANITA
IceCube
Auger
TA

multi-messenger astronomy!
textbook knowledge on supernovae
nearly no mention of gamma-rays

Major breakthroughs in the last 30 years:

- gamma-ray astronomy
- SN1987A
Major breakthroughs in the next 30 years:

- **neutrino astronomy**
- **SN203**

Detecting cosmogenic neutrinos:
- Detection of 1000s of neutrinos (not counting SN202*)
- A dozen of neutrino sources identified
- Time-variable signatures in neutrinos

**GRAND**

- Deployment envisioned 2020s
- Is a huge scalable project

*Giant Radio Array for Neutrino Detection*
Major breakthroughs in the next 30 years:

- Neutrino astronomy
- Multi-messenger astronomy
- SN202*

- Detection of 1000s of ultrahigh energy cosmic rays
- A dozen of sources identified

- Catalog of > 700 TeV sources in 9 different source classes
- > 100 unidentified sources which have no counterparts in other wavelengths

~ 30 years from now (2042)

- Alerts sent to all multi-messenger observatories when high-energy event observed in gamma/nu/cr

JEM-EUSO

CTA
~ 30 years from now (2042)

- particle acceleration region/energy/mechanisms will be directly probed
- < 10 pc-scale gamma-ray features observed in SN202*
- precision neutrino spectrum with 100s of events from PeV to EeV
- no cosmic rays yet due to deflections: wait another 30-60 yrs

- everything will be ready to scrutinize the onset and evolution of next local supernova
~ 30 years from now (2042)

- powerful PIC simulations will have modeled the efficient acceleration of particles in various outflows
- radio observatories will provide a map of the intergalactic magnetic fields (of $B > 1nG$)
- stringent constraints on intergalactic B from cascaded electromagnetic emission from blazars
- precise study of deflection of ultrahigh energy cosmic rays, and direct identification of sources

A. Spitkovsky

“energy desert”? [Image of radio observatories]

- a particle detected at $10^{22}$ eV?

PIC simulations

[Image of PIC simulations]

SKA

neutrinos

- supersymmetry
- Dark Matter
- extra dimensions

[Image of mass-energy scale]
Observatories beyond the Earth

- Radio antenna deployment around the crest of a crater of Venus
- thick atmosphere + favorable geography for Venus-skimming air-showers

Lunar laboratory with many telescopes? multi-wavelength/messenger astronomy (NB: idea dates back from 80s)
- Lunar Cerenkov emission for UHECRs and neutrinos

- JEM-EUSO around Jupiter
- larger gas envelope than Earth, could gain 8 orders of mag. in sensitivity

our projects in 2042