Properties of Cosmic Aluminum Nuclei: Results from the Alpha Magnetic Spectrometer

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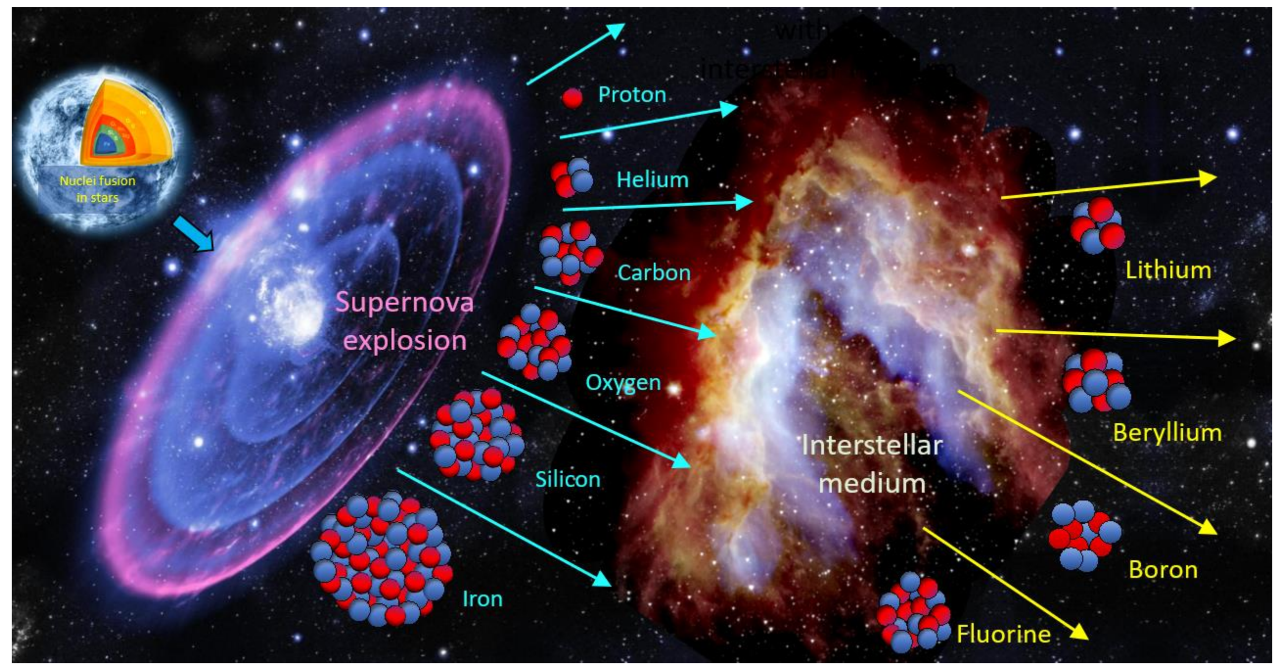
Abstract

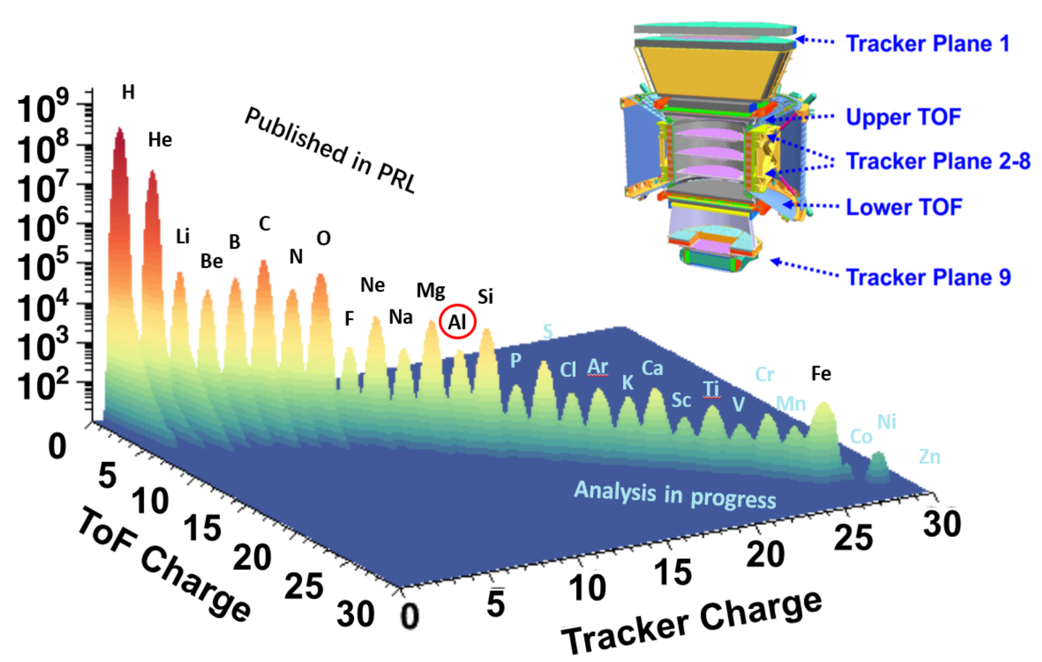
We report the properties of aluminum (Al) cosmic rays in the rigidity range 2.15 GV to 3.0 TV with 0.51 million nuclei collected by the Alpha Magnetic Spectrometer experiment on the International Space Station. We observed that above 6 GV the Al flux is well described by the weighted sum of the silicon flux (primary cosmic rays) and the fluorine flux (secondary cosmic rays). The fraction of primary component increases with rigidity and becomes dominant at highest rigidities. Al/Si abundance ratio at the source is determined independent of cosmic ray propagation models.

Primary and secondary cosmic ray nuclei

- Primary cosmic nuclei (H, He, C, O, Ne, Mg, Si..., Fe) are produced during the lifetime of stars and accelerated in supernovae explosions;
- Secondary cosmic nuclei (Li, Be, B, F, sub-Fe) are produced by the collision of primary cosmic rays with the interstellar medium;
- N, Na and Al are produced both in astrophysical sources and by collisions of heavier nuclei with the interstellar medium.



AMS cosmic ray nuclei measurements

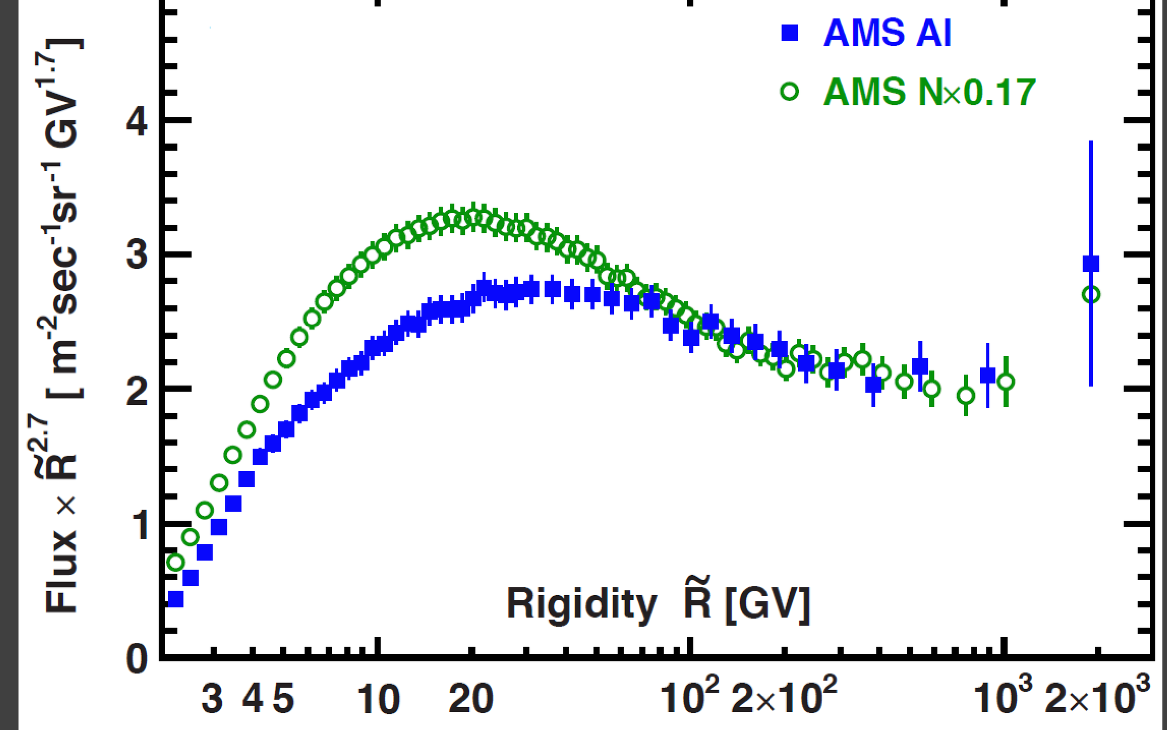


- Two classes of primary cosmic rays, He-C-O and Ne-Mg-Si;
- Two classes of secondary cosmic rays, Li-Be-B and F;
- N flux is well described by the sum of a primary and a secondary component.

See details in AMS Talks on cosmic ray nuclei in CRD (Cosmic Ray Direct) session.

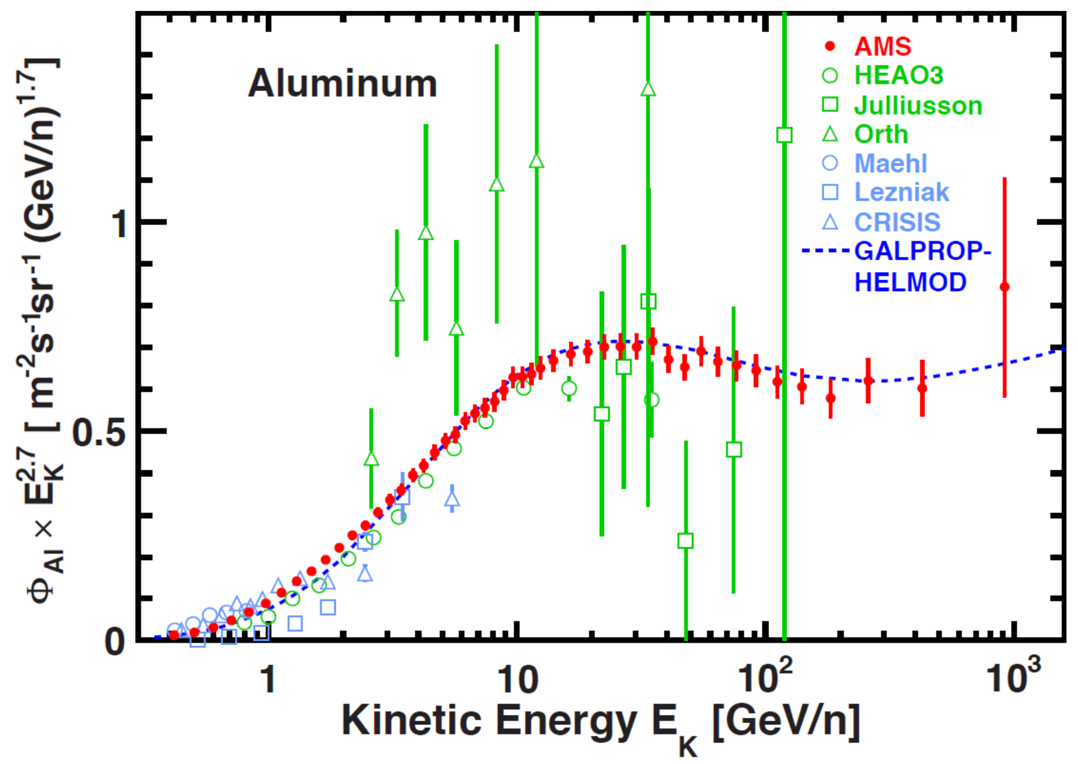
Aluminum flux

The AMS aluminum flux together with the rescaled AMS nitrogen flux multiplied by $R^{2.7}$ with total errors as a function of rigidity.
As seen, at rigidities above 100 GV, the aluminum flux follows the nitrogen flux rigidity dependence.



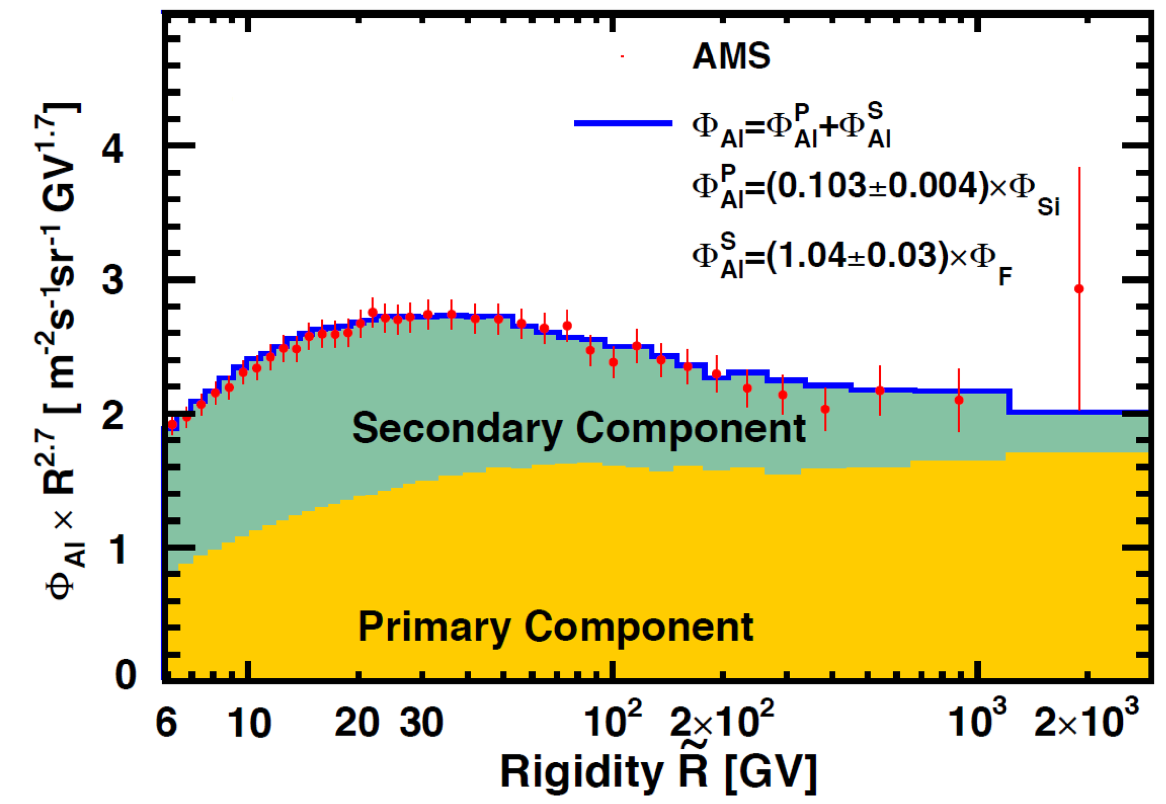
Aluminum flux

The AMS Al flux as function of kinetic energy per nucleon E_k multiplied by $E_k^{2.7}$ together with earlier measurements.



Result

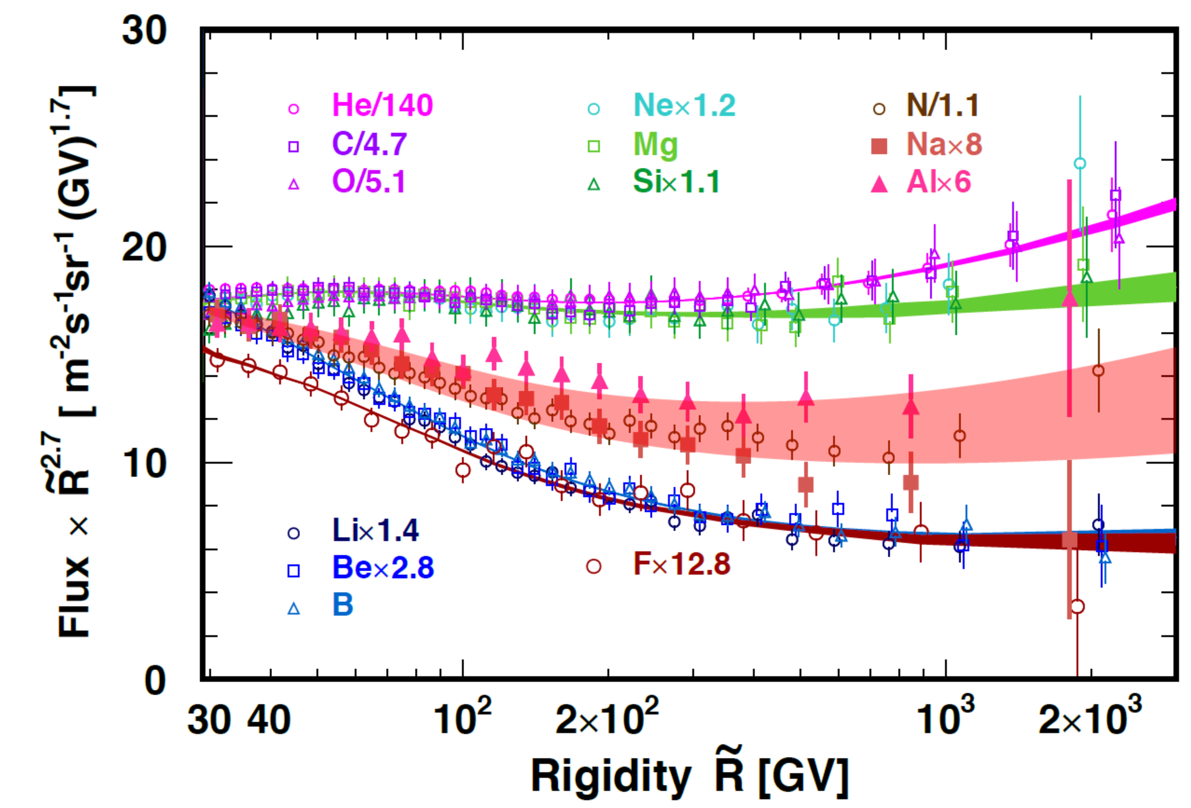
To obtain the primary Φ_{Al}^{P} and secondary Φ_{Al}^{S} components in the Al flux $\Phi_{Al} = \Phi_{Al}^{P} + \Phi_{Al}^{S}$, a fit to the weighted sum of the silicon flux and the fluorine flux was performed above 6 GV.



The primary fraction of the Al flux increases with rigidity: (43 + 1)% at 6 GV, (67 + 1)% at 100 GV, and (78 + 8)% at 2 TV.

Result

Cosmic nuclei fluxes measured by AMS as a function of rigidity from He (Z = 2) to Si (Z = 14).



N, Na, and Al belong to a distinct group and are the combinations of primary and secondary cosmic rays.

Conclusions

we have presented the precision measurement of Al flux as function of rigidity from 2.15 GV to 3.0 TV.

We found that Na and Al, together with N, belong to a distinct cosmic ray group and are the combinations of primary and secondary cosmic rays.
Al flux is well described by the sum of a primary cosmic ray component (proportional to the silicon flux) and a secondary cosmic ray component (proportional to the fluorine flux). The fraction of the primary component increases with rigidity for the N, Na, and Al fluxes and becomes dominant at the highest rigidities.
The Al/Si abundance ratio of 0.103 ± 0.004 at the source is directly determined independent of cosmic ray propagation.

These are new and unexpected properties of cosmic rays.

Reference

M. Aguilar, et al. (AMS Collaboration). Properties of Cosmic Sodium and Aluminum Nuclei: Results from the Alpha Magnetic Spectrometer. **Physical Review Letters**. In Press.

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