Enhancements in the lunar exosphere seen in LACE data

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EPSC, BERLIN, GERMANY 2018
P53C-2241

Abstract. Apollo 17 carried a miniature mass spectrometer, called the Lunar Atmospheric Composition Experiment (LACE), to the Moon as part of the Apollo Lunar Surface Experiments Package (ALSEP) to study the composition and variations in the lunar atmosphere [1]. During an analysis of these data a sudden increase in many, but not all, of the atomic species was discovered during the 5th lunation. The solar wind plasma flux was elevated during the entire 10 hour period preceding the enhancements in exospheric density observed by LACE. The maximum in the solar wind plasma flux during this time period was measured by the IMP-6 spacecraft in Earth orbit at 20:00 hours on May 6, about four hours prior to the observed density enhancement on the nightside. However, our Monte Carlo models cannot reproduce the observed sudden increase in ^{20}Ne with the increase in the solar wind flux at the Moon. With known source and loss parameters, there have been no successful models of Ne in dynamic equilibrium with the solar wind. We found evidence for seismic activity 55 days before the May 7, 1973 enhancement [2]. This corresponds to the time when the density vs. lunation began to increase. Hodges reported enhancements in the Ar densities around this time [3]. Alternative explanations may involve a small meteoroid impact.

Introduction

•The LACE data were available for mass/charge (M/Q) 1 to 100, but the usable data are in the range 16 - 45 AMU/Q. The raw data are in counts per 0.6 second. The first task was therefore to calibrate the data. There is no available calibration for the LACE mass spectrometer data, however, a similar instrument was constructed and flown on the Pioneer Venus mission [4] and we used their calibration. Looking closely at the variation of the mass 20 peak over the 9 available lunations, a sudden increase of peak in the later part of 5th lunation was seen. A mass 20 peak suddenly appeared at 00.38 UT on May 7th, 1973. We then saw that the other masses were increased, but by varying amounts (Figure 1). We show in Table 1 the ^{20}Ne densities estimated from the Pioneer Venus neutral mass spectrometer calibration curve.

Table 1: ^{20}Ne densities estimated for lunations 2 - 5

LUNATION	^{20} NE DENSITY CM^{-3} X10^{3}
2ND	1.5 – 3.5
3RD	2.0 – 4.5
4TH	2.0 – 4.0
5TH BEFORE & AFTER	2.0 – 4.0
5TH INCREASED	27.4

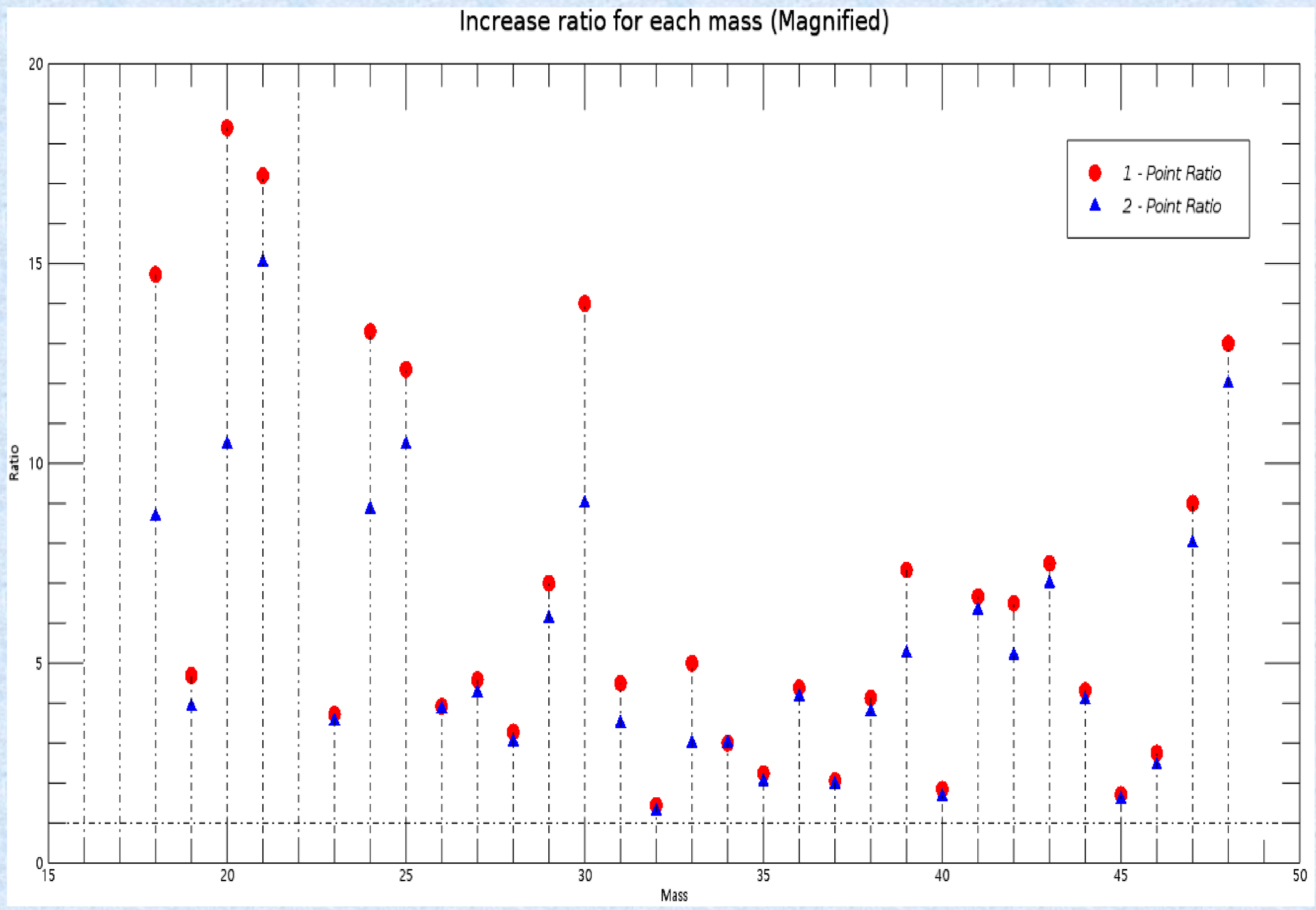

Figure 1. Increase Ratio for M/Q 15 - 20

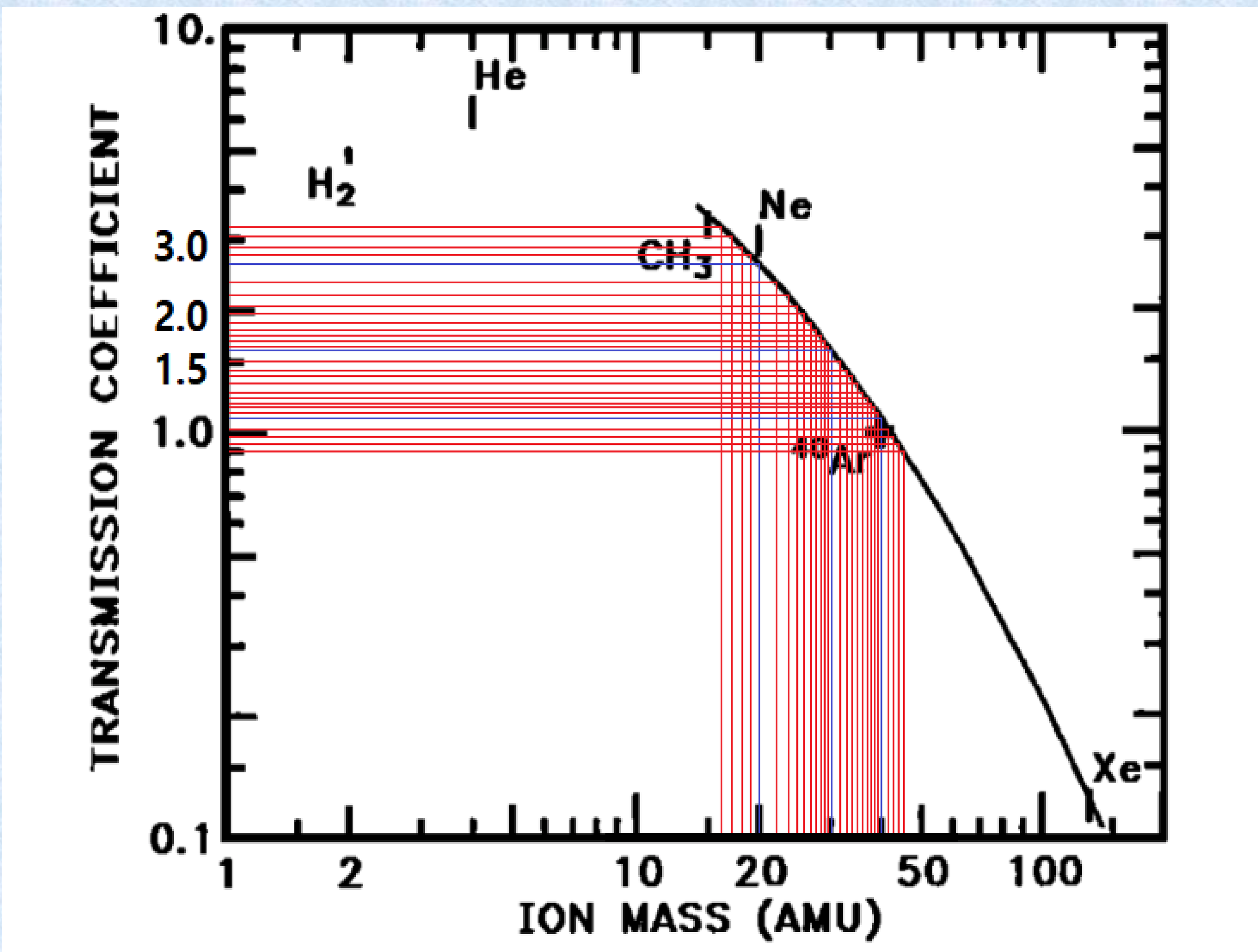

Figure 2. Transmission coefficients used for ion mass to charge, M/Q, 1 - 100 AMU based on Pioneer Venus neutral mass spectrometer.

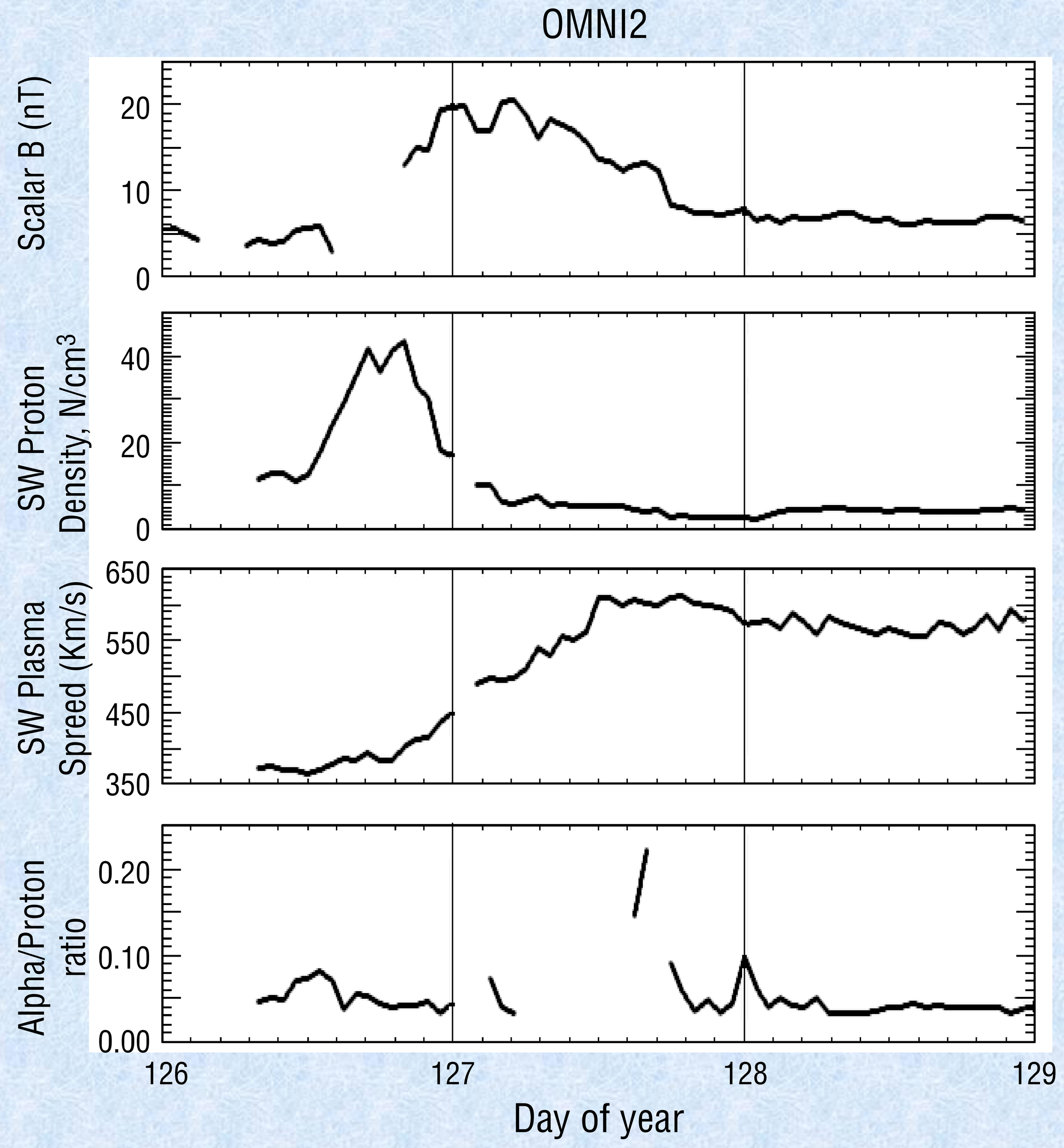

Figure 3. Solar wind parameters, magnetic field strength, number density plasma speed and alpha to proton ratio for DOY 126 - 128, 1973, from the NASA OMNI website (IMP-6 data).

CONCLUSIONS

If we assume CME conditions persisted for 4.5 days, the column abundance at the subsolar point would be N(Ne)=3x10^{10} cm^{-2}. However we have not been able to reproduce the measured rapid increase and rapid decline in ^{20}Ne with our Monte Carlo model using the measured solar wind flux and assuming dynamic equilibrium with the solar wind and an exosphere accommodated to the local surface temperature. However, our elevated value of ^{20}Ne matches that reported by Benna et al., 2015 [5] attributed to coincide with a CME at the Moon.

Acknowledgements
Killen and Tucker were supported by the DREAM2 team of SSERVI. SJK and JKP acknowledge support from the Space Core Technology program through NRF funded by the Ministry of Education, Science and Technology, Republic of Korea. David Williams is supported by NSSDCA.

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