NOTIZEN

A Redetermination of the Isotopic Composition of Atmospheric Neon

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A redetermination of the isotopic composition of atmospheric neon gave abundance ratios $^{20}Ne/^{22}Ne = 9.80 \pm 0.08$ and $^{20}Ne/^{21}Ne = 338.0 \pm 2.5$, corresponding to percentage abundances of 90.50 ± 0.07, 0.268 ± 0.002 and 9.23 ± 0.07 for ^{20}Ne, ^{21}Ne and ^{22}Ne, respectively. These abundances correspond to an atomic weight of 20.179 ± 0.002 for atmospheric neon.

During measurements of neon in meteorites we observed that our standards of terrestrial neon showed an isotopic composition consistently different from the currently accepted value. Preliminary checks indicated that this difference seemed neither due to isotopic fractionation in the mass spectrometer nor to fractionation during sample preparation. Thus we decided to make a redetermination of the isotopic composition of atmospheric neon.

Mass Spectrometer Used

Most measurements were made with a single focussing, 60 degree, 10 cm radius of curvature, all glass mass spectrometer. No source magnet was used. The spectrometer had a Faraday-cup collector with a Cary vibrating reed electrometer. The ion current detection system was calibrated with a precision potentiometer and subsequent small corrections for non-linearity etc. were applied. The linearity of the input resistors was measured by the capacitor discharge method and was better than 0.1%. Also, measurements with different input resistors (10^{11} and 10^{10} ohms) gave the same ratios.

The spectrometer was normally used for measuring rare gas samples from meteorites and was operated statically. No memory was detected for neon. Corrections due to background on masses 20, 21 and 22, including Ar^{++} and CO_2^{++} ions were for most runs below 10^{-3}. The neon isotopic ratios showed no dependence on the partial or total gas pressure in the mass spectrometer, even at pressures at which the linearity between pressure and ion current discontinued to hold. Thus, it was not necessary to separate helium and neon prior to the mass spectrometric measurement. Nevertheless, each sample was measured at several different pressures.

The $^{20}Ne/^{21}Ne$ ratio was also determined on our Atlas CH4 mass spectrometer. In this case we used the $^{20}Ne/^{22}Ne$ ratio in order to calibrate the spectrometer for mass discrimination. The discrimination was only 0.5% per mass unit, despite the use of a source magnet.

Mass Discrimination

Measurements of a $^{3}He-^{4}He$ mixture with known isotopic composition showed that the mass spectrometer had a very small mass discrimination when used without a source magnet (about 1.5% for the $^{3}He/^{4}He$ ratio). Furthermore, extreme defocussing of the source led to only very small variations in the measured $^{20}Ne/^{22}Ne$ ratio (less than 3% for an intensity supression by a factor of 15). Nevertheless, an isotopic neon standard was prepared by mixing known amounts of atmospheric neon with enriched ^{22}Ne (enriched to 99.7%). This isotopic standard had a composition of

$$^{20}Ne/^{22}Ne = 0.679 \pm 0.005\,.$$

The mass spectrometer was subsequently always calibrated with this mixture. The discrimination for neon was less than 0.3% per mass unit, in agreement with the small discrimination found for helium.

Preparation of Neon Samples

It cannot be assumed, a priori, that commercially available pure nean has not undergone fractionation during the separation processes. We thus prepared samples of atmospheric neon, using the following two different cleaning and separation procedures:

a) Removal of O_2, N_2 etc. with hot titanium sponge heated by induction in a water cooled extraction vessel. Then separation of Ar, Kr and Xe from the light rare gases by adsorption in a charcoal trap at liquid air temperature. No further separation of neon from helium. Release and readsorption from the charcoal showed that less than 0.1% of the neon was adsorbed on the charcoal.

b) Removal of O_2, N_2, Ar etc. with a charcoal trap at liquid air temperature. No further separation of neon from helium. Less than 0.3% of the neon was adsorbed on the charcoal.

All samples and standards went through the same additional cleaning process at the sample inlet system of the mass spectrometer (hot titanium foil, hot CuO, charcoal trap at liquid air temperature). The helium/neon ratio in the samples prepared according to both procedures was the same within the experimental error (± 5%).

Discussion

Table 1 shows the results. The listed errors are three times the standard error (standard deviation of the mean value). All values have been corrected for mass discrimination, but the indicated error does not contain the uncertainty in the absolute isotopic composition of the isotopic neon standard. All measurements agree very well within the errors. This indicates that also our commercially available pure neon shows no isotopic fractionation.

Sample	$^{20}Ne/^{22}Ne$	$^{20}Ne/^{21}Ne$	Remarks
Pure Neon (Linde)	9.800 ± 0.030	339.0 ± 2.0	
Air Neon A	9.795 ± 0.035	337.5 ± 2.5	b
Air Neon B	9.800 ± 0.035	338.0 ± 1.5	a
Air Neon C	9.795 ± 0.050	—	b
Pure Neon (Linde)	—	338.5 ± 2.0	c

[a] Prepared from air according to procedure a),
[b] Prepared from air according to procedure b),
[c] Measured on Atlas CH4 mass spectrometer.

Table 1. Isotopic composition of different air neon samples. The errors are three times standard error. The values are corrected for mass discrimination, but the error does not include the uncertainty of our isotopic neon standard.

	$^{20}Ne/^{22}Ne$	$^{20}Ne/^{21}Ne$	$^{22}Ne/^{21}Ne$
This paper	9.800 ± 0.080	338.0 ± 2.5	34.50 ± 0.30
NIER [1]	10.305 ± 0.045	353.7 ± 0.8	34.32 ± 0.08
DIBELER, MOHLER, and REESE [2]	9.83 ± 0.19	323 ± 23	32.9 ± 2.3
HIBBS [3]	9.26 ± 0.01	300 ± 10	32.4 ± 1.1
VAUGHAN, WILLIAMS, and TATE [4]	9.25 ± 0.08	337 ± 20	36.4 ± 2.2

Table 2. Comparison of our results with literature values. The errors are taken from the original publications, and may be defined differently (see original publications). The error of our results includes the uncertainty of our isotopic neon standard.

Table 2 gives a comparison of our results with previous determinations. The $^{20}Ne/^{22}Ne$ and $^{20}Ne/^{21}Ne$ values given by NIER [1] are definitely higher, whereas the $^{22}Ne/^{21}Ne$ ratio agrees quite well with our value. NIER explicitly states, that his neon sample might have been fractionated. If this is indeed true then the good agreement of the $^{22}Ne/^{21}Ne$ ratio would be accidental. In all the other previous determinations the mass spectrometer was not checked for possible discriminations and thus no great significance can be attached to either agreement or disagreement with our results.

The abundance ratios found in our work correspond to percentage abundances of 90.50 ± 0.07, 0.268 ± 0.002 and 9.23 ± 0.07 for ^{20}Ne, ^{21}Ne and ^{22}Ne respectively. With isotopic weights of ^{20}Ne, ^{21}Ne and ^{22}Ne of 19.9924, 20.9939 and 21.9914 respectively ($^{12}C = 12$ scale, KÖNIG, MATTAUCH, and WAPSTRA [5]) one calculates an atomic weight of 20.179 ± 0.002 for neon. This value is in fair agreement with the international value of 20.183 based upon gas density measurements (BAXTER and STARKWEATHER [6], see also CAMERON and WICHERS [7]).

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Mattauch–Herzog Type Mass Spectrograph with Two-Stage Electrostatic Field

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MATTAUCH–HERZOG type mass spectrographs for chemical analysis of solid material using a spark ion source are powerful. But one point of disadvantage is the fact that the energy slit cannot control the energy spread (β) independently of beam divergence (α). Therefore, even when the energy slit is narrowed to an infinitesimal width, the ion beam which enters the magnetic field still has a wide energy spread.

If two electrostatic fields are substituted for the usual single electrostatic field, a real image of the ion source being formed between the two fields and the energy defining slit being set there, then the energy spread can be controlled independently of beam divergence.

If the electrostatic fields are produced by cylindrical condensers with equal radii as shown in Fig. 1, then the positions of source and image with respect to the electrostatic fields, under the first-order double focusing condition for all masses, are given by the following equations

$$\frac{l_1}{r_e} = \frac{(1/\sqrt{2})\, D_3 \cos\sqrt{2}\,\varphi_{e1} + \sin\sqrt{2}\,\varphi_{e2}\{1-(1\mp 1)\cos\sqrt{2}\,\varphi_{e1}\}}{\{D_3-\sqrt{2}\,(1\mp 1)\sin\sqrt{2}\,\varphi_{e2}\}\sin\sqrt{2}\,\varphi_{e1}},$$

$$\frac{l_2}{r_e} = \frac{D_3-\sqrt{2}\sin\sqrt{2}\,\varphi_{e2}\,(1\mp 1-\cos\sqrt{2}\,\varphi_{e1})}{2\sin\sqrt{2}\,\varphi_{e1}\sin\sqrt{2}\,\varphi_{e2}}, \quad \frac{l_3}{r_e} = \frac{1}{\sqrt{2}}\cot\sqrt{2}\,\varphi_{e2}.$$