Making CHILI: A progress report

A.M. DAVIS[1,2,3]*, T. STEPHAN[1,2], M.J. PELLIN[1,2,3,4], I.V. VERYOVKIN[1,4] AND M.R. SAVINA[1,4]

[1]Chicago Center for Cosmochemistry
[2]Dept. of Geophysical Sciences, Univ. of Chicago, Chicago, IL 60637 (*correspondence: a-davis@uchicago.edu)
[3]Enrico Fermi Inst., Univ. of Chicago, Chicago, IL 60637
[4]Materials Science Div., Argonne National Laboratory, Argonne, IL 60439

Each increase in lateral resolution of micro- or nanoanalytical instruments has revealed new worlds. The Stardust mission returned two types of samples, cometary dust and contemporary interstellar dust (although the latter is not yet confirmed), that clearly point to a need for improvements in lateral resolution and sensitivity beyond what is available with current state-of-the-art secondary ion mass spectrometry (SIMS) instruments. SIMS lateral resolution has reached ~50 nm and useful yields (atoms counted per atom removed from the sample) are at most a few percent for easily ionized atoms but can be much lower. We are in the midst construction of CHILI (the CHicago Instrument for Laser Ionization), a resonant ionization mass spectrometry (RIMS) instrument designed for isotopic and chemical analysis at the few-nm scale with a useful yield of 35–50% [1]. CHILI will combine a high resolution liquid metal ion gun (LMIG) that can be focused to <5 nm, tunable solid state lasers for laser resonant ionization, and a time-of-flight mass spectrometer. It will be equipped with an electron gun for secondary electron imaging, as optical imaging is diffraction-limited to ~0.5 μm. The physical layout will also be different from previous instruments [2, 3], with the flight tube of the ion nanoprobe mounted vertically above the sample chamber; this assembly is mounted in the center of an H-shaped laser table equipped with active vibration cancellation devices. Isotopic precision in RIMS can be limited by the temperature stability of photoionization lasers [4], so a thermally stabilized, low-vibration, draft-free room to house CHILI was recently completed. The laser table, sample chamber, a nanomotion stage, and a low-vibration vacuum system are now in place. Existing ion optical components are now being modified for high voltage operation, construction of the time-of-flight mass spectrometer is about to begin, with tunable lasers for photoionization of at least two elements simultaneously to follow shortly thereafter.

[1] Stephan *et al.* (2010) *LPS* **41**, #2321. [2] Savina *et al.* (2003) *GCA* **67**, 3215. [3] Veryovkin *et al.* (2008) *LPS* **39**, #2396. [4] Levine *et al.* (2009) *Int. Jour. Mass Spectrom.* **288**, 36.

A Bayesian approach to averaging and error estimation: Application to ^{87}Rb decay constant measurements

D.W. DAVIS

Department of Geology, University of Toronto, 22 Russell St., Toronto, ON M5S 3B1, Canada
(*correspondence: dond@geology.utoronto.ca)

Rotenberg *et al.* [1] have reported a set of precise measurements of the ^{87}Rb decay constant (λ87) with excessive scatter. A frequency plot of the measurements suggests that the unknown error is unidirectional upwards and has a quasi-linear or half-gaussian distribution. In order to avoid the problem of data censoring and allow for the inference that at least some sources of error follow a non-normal distribution, a Bayesian approach to analysis of the data has been used. Classical statistical inference assumes that the parameter being measured, in this case λ87, has a well-defined (although imprecisely known) value and error bars are normally put around data. In the present approach, errors are associated with the measurement processes and apply to the parameter, not the data. The difference is largely philosophical, but the present problem can be more easily formulated in these terms. We consider a possible value of λ87 associated with a set of error distributions {σn} related to the set of measurements. The error distributions for one estimate of λ87 are the convolution of the set of known normally distributed measurement errors and a postulated half-gaussian (upward) bias distribution taken as having a width of σB. A relative probability that the data set could have been generated randomly if λ87 and σB had the postulated values is calculated. Repeating this procedure for a range of λ87 and σB estimates defines a two dimensional manifold of relative probability density in 3-space. The best estimates of λ87 and σB should lie at or around the peak of this surface, while the upper and lower 95% confidence errors can be determined by partial integrations of the projected curves.

For the set of 15 most precise data in [1], the 3-dimensional peak gives 1.3956 (x 10-11/year understood) for λ87 and 0.0027 for σB, while the median and 95% confidence errors of the curve projected onto the λ87 axis are 1.3955+4/-6 (36% probability of fit). Very similar values are found for the full 28 point data set. The averages are lower than the lowest measurements, which is less surprising when it is considered that the data have been skewed upward by the unspecified source of error. This general approach may also be useful in other cases where non-normal error distributions are suspected or inferred.

[1] Rotenberg, Davis & Amelin (2010) *GCA*, this volume.