

## **Results of the Survey of Critical Use of $^3\text{He}$ for Cryogenic Purposes**

Northwestern University  
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The rare isotope of helium,  $^3\text{He}$ , has critical strategic importance. One of its applications is to achieve low temperatures through refrigeration and measuring devices, mostly in the pursuit of fundamental knowledge, providing the essential building blocks for engineering and technology for our future. Cryogenic use of  $^3\text{He}$  is critical in that there is no alternative to reaching a range of more than 4 orders of magnitude of temperature from 1 K to as low as  $10^{-4}$  K. Here basic scientific investigations require  $^3\text{He}$  for the study of quantum systems, including information technology, magnetism, and superconductivity. Its recent short supply and extraordinary high price has posed serious problems for the scientific community. The purpose of this survey was to document as accurately as possible world-wide use of  $^3\text{He}$  in the past ten years as a framework for future cryogenic allocations and to evaluate the impact of research that uses  $^3\text{He}$ .

The survey is restricted to senior or principal scientific investigators, who are representatives of their respective research groups. The survey solicitation was sent to the e-mail list serves of the International Conference on Low Temperature Physics, LT25; the International Symposium on Quantum Fluids and Solids, QFS2009; a list of principal investigators using cryogenic  $^3\text{He}$  in their research grants from the National Science Foundation, the Program in Condensed Matter Physics; a list of principal investigators using cryogenic  $^3\text{He}$  in their research grants from the Department of Energy, the Program in Basic Energy Sciences. These totaled approximately 2,300 including members of the communities including students, research associates, postdoctoral fellows, scientists, and finally, the principal or senior investigators who were asked, on behalf of their groups, to respond to the survey.

This survey and a copy of the results were posted at:  
<http://www.qfs2009.northwestern.edu/survey/>

## Survey Results:

Number of senior investigator respondents:	206
USA respondents:	98
Total $^3\text{He}$ purchases, yearly average over ten years:	3,469 L/year
maintenance and samples gas from research groups:	1,141 L/year
new instruments (mostly refrigerators) from companies:	2,328 L/year
$^3\text{He}$ for cryogenic purposes purchase last year (2009):	3,828 L
Price of $^3\text{He}$ last year, average (2009):	930 \$/L
Scientific programs requiring cryogenic $^3\text{He}$ (fraction of total):	
Quantum Fluids and Solids	8 %
Superconductivity	24 %
Quantum Information	7 %
Mesoscopic Physics	12 %
Magnetism	12 %
Electronic Materials	10 %
Quantum Resonators	3 %
Quantum Transport	12 %
Refrigeration Instrumentation	8 %
Detector Instrumentation	3 %
Other	2 %
Graduate student training using cryogenic $^3\text{He}$ , graduated in ten years:	3,349 students
Postdocs hired in ten years using cryogenic $^3\text{He}$ :	2,322 postdocs
Research funding in ten years requiring cryogenic $^3\text{He}$ :	2.65 billion \$

### *Comments on growth in the cryogenic use of $^3\text{He}$ :*

Sufficient information in the responses was given to determine the following growth in requirements for cryogenic use of  $^3\text{He}$ . Yearly increases in purchases for cryogenic  $^3\text{He}$  are 12% per year on average. The increase in cost in the past three years has been approximately a factor of 4 to 5 on average.

2005	23 %
2006	- 1 %
2007	30 %
2008	- 20 %
2009	26 %
yearly average	12 %

### *Comments on impact from research that uses cryogenic $^3\text{He}$ :*

The significant impact of research that uses cryogenic  $^3\text{He}$  includes 335 graduate student PhD's awarded per year and 232 postdoctoral fellows hired per year (numbers adjusted for response rates determined as described in b) below averaged over the past ten years). Additionally, all theoretical work related to experimental

research that uses cryogenic  $^3\text{He}$  would not have taken place without this range of temperature for quantum condensed systems, substantially increasing the student, staff, and funding impacts beyond that shown in this survey.

*Reporting methodology:*

- a) The following nine companies provide cryogenic  $^3\text{He}$  instrumentation and reported their sales of  $^3\text{He}$ , presented above in aggregate form: Bluefors, Chase Research Cryogenics, Cryomagnetics (including Cryoconcepts), Janis Research, Lakeshore Cryotronics, Leiden Cryogenics, Oxford Instruments, Quantum Design.
- b) Purchases of  $^3\text{He}$ , not as a part of commercial instrumentation, made by individual research groups, reported above, were adjusted by a survey response fraction of 51%. This fraction is defined by the USA pool and was assumed to be valid elsewhere in the world. The fraction is defined as the number of USA principal investigators responding to the survey divided by the total number of funded USA principal investigators identified by program managers from the NSF/CMP and the DOE/BES. Error in corrections for survey response rate is relatively small since 2/3 of the cryogenic  $^3\text{He}$  is purchased by the instrumentation companies for which we have an accurate total response.
- c) The responses were examined one-by-one to avoid duplication and improper submission and to be sure that each submission represented only one research group.