CHARACTERIZATION OF SUPERCONDUCTING AND MAGNETIC MATERIALS WITH MUON SPIN ROTATION AND NEUTRON SCATTERING

COMBINED

Progress Report
March 1996 - August 1997

&
Final Report
June 1988 - August 1997

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Final Report

June 1988 - August 1997

Research Activities

This report represents the culmination of over nine years of research activity in the study of superconducting and magnetically ordered materials using the muon spin rotation (μ SR) and neutron scattering techniques on the part of physics faculty and students of Virginia State University and supported by the United States Department of Energy through its Division of Basic Energy Sciences/Materials Sciences Division. Because all the activities that took place up until March 1996 have been covered in previous annual reports, this final report includes only a brief overview of activities prior to that date, and concentrates on the period from March 1996 through August 1997.

The primary activity undertaken in this project has been studies of high-temperature superconductors and their close chemical relatives (which, for the most part, display anti-ferromagnetic or spin glassy behavior at sufficiently low temperatures) with the μ SR technique. These experiments extend from early work done with a relatively primitive muon beam at the AGS of Brookhaven National Laboratory and large polycrystalline samples of the earliest known high- T_C materials to studies of very small high-purity single crystals of the best high- T_C materials currently available using the highest quality surface muon beams and specially-designed low-background spectrometers at the Tri-University Meson Facility (TRIUMF) in the past three years.

During the period since the last annual report five μ SR experiments were done at TRIUMF with DOE support (plus two more with new support from the Air Force Office of Scientific Research). A study of single-crystal high-temperature superconductors was done in July 1996. The VSU team on this experiment consisted of C.E. Stronach, D.R. Noakes, and graduate student M.F. White, Jr., and it was done in collaboration with the University of British Columbia team headed by J.H. Brewer. A study of the quasicrystal materials $Gd_8Mg_{42}Zn_{50}$ and $Tb_8Mg_{42}Zn_{50}$ was done by D.R. Noakes in collaboration with G.M. Kalvius of the Technical University of Munich and R. Wäppling of Uppsala University (Sweden) during the first week of December 1996. During the second week of December 1996 a study of the cryocrystals CH_4 and CF_4 (both in the solid phase) was done by D.R. Noakes in collaboration with S. Storchak of Moscow State University and J.H. Brewer of the University of British Columbia. A study of high- T_C superconductors ($Y_{0.8}Ca_{0.2}$ -123 crystal, optimally doped; $Y_{0.8}Ca_{0.2}Cu_3O_{6.6}$ underdoped; $YBa_2Cu_4O_8$) was done at TRIUMF during the third week of December 1996 by C.E. Stronach and D.R. Noakes, plus C. Bernhard of the Max

Planck Institute - Stuttgart and M. Heuberger, a graduate student at the University of Konstanz. In February 1997 Stronach and Noakes joined A. Kratzer of the Technical University of Munich and R. Wäppling in a study of GdMn_2 , hexagonal CeCuSn , and the spinel $\text{Mn}_{0.4}\text{Zn}_{0.6}\text{Fe}_2\text{O}_4$.

Thesis Projects Completed by Students

Since the last annual report three VSU graduate students have completed their M.Sc. Degrees with thesis projects done under the ægis of this DOE-supported program:

- **Jacob R. Brankley** (May 1996): *Muon Spin Relaxation Studies of Praseodymium Cuprate High-Temperature Superconductors*
- **Muhammad M.K. Sarker** (May 1997): *Muon Spin Relaxation Study of $\text{Cd}_{1-x}\text{Mn}_x\text{Te}$*
- **Xuewen Wan** (May 1997): *ZF- μSR Study of the Interplay between Antiferromagnetism and Superconductivity in Low-Carrier-Density Regime $\text{Y}_{1-x}\text{Ca}_x\text{Ba}_2\text{Cu}_3\text{O}_6$*

Previously, thirteen VSU graduate students completed their M.Sc. degrees under the advisement of Stronach and Noakes, ten of them with DOE support:

- **Howard P. Cooke** (May 1992): *Muon Spin Rotation Studies of $\text{YBa}_2\text{Cu}_3\text{O}_7$ Doped with Iron*
- **Melvin U. Spurlock** (May 1992): *Muon Spin Relaxation Studies of Titanium Hydride*
- **Keith C. Hepburn-Wiley** (July 1992): *Muon Spin Rotation Studies of $\text{YBa}_2\text{Cu}_3\text{O}_7$ Doped with Nickel and Zinc*
- **Michael R. Davis** (May 1993): *Muon Spin Rotation Study of Magnetic Ordering in $\text{Nd}_{2-x}\text{Ce}_x\text{CuO}_{4-y}$*
- **Peter E. Radcliff, Jr.** (May 1993): *Muonium and Muonated Radical Formation in Pure and Doped Fullerenes*
- **Adnan N. Ismail** (July 1993): *Muon Spin Relaxation Studies of Quasicrystals*

- **Randolph S. Cary** (May 1995): *Development of Programs in FORTRAN to Analyze Muon Spin Rotation Data*
- **Vaughn B. McMullen** (July 1995): *Simulation of Magnetic Field Distributions in Dilute Materials*
- **Timbangan Sembiring** (July 1995): *Studies of the Flux-Penetration State in High- T_C Superconducting Materials Containing Bismuth and Mercury by Muon Spin Relaxation*
- **Mary-Ann Blankson-Mills** (July 1995): *Muon Spin Rotation Studies of Superconducting Doped (Y,Ca)Ba₂Cu₃O_{6+δ} Compounds*
- **Hassan J. Llewellyn** (May 1993, support from a NASA grant): *Photomultiplier Tests for the CEBAF Large Acceptance Spectrometer Time-of-Flight System*
- **Peter Chow** (July 1993, support from a NASA grant): *Track Finding with Neural Networks*
- **Jane G. Fowler** (July 1995, support from a NASA grant): *Analysis of the Spectrum of De-excitation Gamma Rays Following the Interaction of 720-MeV Alpha Particles with Calcium Nuclei*

Recent Publications

Since the submission of the last annual report the following papers have been published by the VSU investigators supported by this program, with their collaborators from other institutions (a cumulative list of all publications for the duration of the support period, June 1988 through August 1997, is included as an appendix to this report):

The influence of impurities and alloying in the Kondo semimetal CeNiSn as seen by μ SR
 G.M. Kalvius, T. Takabatake, A. Kratzer, R. Wäppling, **D.R. Noakes**, S.J. Flaschin,
 F.J. Burghart, R. Kadono, I. Watanabe, A. Brückl, K. Neumaier, K. Andres, K.
 Kobayashi, G. Nakamoto and H. Fujii
 Hyperfine Interactions **104** (1997) 157.

Texture effect on vortex-state TF- μ SR in Bi-2223 high- T_c superconductors

R.I. Grynszpan, P.L. Langlois, **D.R. Noakes**, **C.E. Stronach**, **M.M. Granderson**,
E.J. Ansaldo, J.R. Brownstein, A.J. Hill and T.J. Bastow
Hyperfine Interactions **105** (1997) 95.

A μ SR study of the superconducting condensate density in high-temperature superconductors

C. Niedermayer, C. Bernhard, J.L. Tallon, G.V.M. Williams, J.I. Budnick, E.J. Ansaldo, **C.E. Stronach**, **D.R. Noakes**, C. Bucci, R. DeRenzi and G. Guidi
Hyperfine Interactions **105** (1997) 139.

Muons and muonium in Zn spinels

F.J. Burghart, W. Potzel, G.M. Kalvius, W. Schiessl, A. Kratzer, E. Schreier, A. Martin, M. Hillberg, R. Wäppling and **D.R. Noakes**
Hyperfine Interactions **106** (1997) 187.

Concentration dependence of critical scattering from Cr(V) alloys above the Néel temperature

D.R. Noakes, E. Fawcett and T.M. Holden
Physical Review B **55** (1997) 12504.

Magnetic field dependence of the London penetration depth in the vortex state of $\text{YBa}_2\text{Cu}_3\text{O}_{6.95}$

J.E. Sonier, R.F. Kiefl, J.H. Brewer, D.A. Bonn, S.R. Dunsiger, W.N. Hardy, R. Liang, W.A. MacFarlane, T.M. Riseman, **D.R. Noakes**, **C.E. Stronach**
Physical Review B **55** (1997) 11789.

μ SR magnetic response of CeNiSn on impurity content

A. Kratzer, G.M. Kalvius, S.J. Flaschin, **D.R. Noakes**, R. Wäppling, A. Brückl, K. Neumaier, K. Andres, T. Takabatake, K. Kobayashi, G. Nakamoto and H. Fujii
Physica B **230-232** (1997) 661.

μ SR studies of magnetic correlations in Pt- and Cu-doped CeNiSn

G.M. Kalvius, S.J. Flaschin, T. Takabatake, A. Kratzer, R. Wäppling, **D.R. Noakes**,
F.J. Burghart, A. Brückl, K. Neumaier, K. Andres, R. Kadono, I. Watanabe, K. Kobayashi, G. Nakamoto and H. Fujii
Physica B **230-232** (1997) 665.

μ SR studies of the doping dependence of the magnetic response of the Kondo semimetal CeNiSn

S.J. Flaschin, A. Kratzer, F.J. Burghart, G.M. Kalvius, R. Wäppling, **D.R. Noakes**, R. Kadono, I. Watanabe, T. Takabatake, K. Kobayashi, G. Nakamoto and H. Fujii
Journal of the Physics of Condensed Matter **8** (1996) 6967.

μ SR measurement of the fundamental length scales in the vortex state of YBa₂Cu₃O_{6.60}

J.E. Sonier, R.F. Kiefl, J.H. Brewer, D.A. Bonn, S.R. Dunsiger, W.N. Hardy, R. Liang, W.A. MacFarlane, R.I. Miller, T.M. Riseman, **D.R. Noakes**, **C.E. Stronach**, **M.F. White, Jr.**

Physical Review Letters, accepted for publication.

The following papers were co-authored by members of the VSU group that received support from this DOE grant. These papers are not on topics relevant to the grant-supported research and the work done by the VSU personnel was not supported with funds from this grant (a small grant from NASA did provide support). They are listed to provide completeness in terms of the research activities of the involved VSU personnel:

Heavy fragment production cross sections from 1.05-GeV/nucleon ⁵⁶Fe in C, Al, Cu, Pb and CH₂ targets

C. Zeitlin, L. Heilbronn, J. Miller, S.E. Rademacher, T. Borak, **T.R. Carter**, K.A. Frankel, W. Schimmerling and **C.E. Stronach**
Physical Review C **56** (1997) 388.

Pion-nucleus single charge exchange induced by stopped negative pions

R. Nair, H.S. Plendl, E.P. Gavathas, L.-C. Liu, R.J. Estep, B.J. Dropesky, J.D. Bowman, J.N. Knudson, B.J. Lieb, **C.E. Stronach**, H.O. Funsten, J. Mackenzie
Physical Review C **53** (1996) 811.

Several additional papers based on work supported by this grant from the DOE are in the process of being written. They will be sent to the DOE in supplemental reports as they are accepted for publication.

Summary

Several major accomplishments have resulted from this work done by VSU investigators (and their collaborators) and supported by the DOE. Among the most noteworthy are:

- The results of a number of the μ SR experiments done on high- T_C superconductors and their close chemical relatives provided much of the early evidence for a d-wave component to the condensate electron pairs in these materials, and have provided additional evidence of an exotic nature to the pairing mechanism.
- The close relation between high- T_C superconductivity and antiferromagnetism has been reconfirmed and found to be a general phenomenon related to these materials.
- Industrial texturing processes used in the fabrication of Bi-2223-based SC cables have been shown to alter the London penetration depth of these materials.
- The formation of muonium and muonic radicals in fullerene compounds has been observed and used to confirm properties of this new class of materials, including the trapping of impurity species in the C_{60} cages.
- Bizarre magnetic effects have been observed in quasicrystal materials such as I -Al-Mn-Si, i - $Tb_8Mg_{42}Zn_{50}$ and i - $Gd_8Mg_{42}Zn_{50}$, which have not yet been fully explained.
- Through neutron-scattering measurements it has been found that an unexpected and as yet unexplained discontinuity exists in the incommensurability of Cr(V) and Cr(Re) alloys.
- Through an associated DOE grant program for instrumentation, VSU received funds to purchase a dilution refrigerator, which has been set up at TRIUMF through a memorandum of understanding between the laboratory and VSU, and which will serve both VSU investigators and other TRIUMF users in ultra-low temperature studies.
- With support from this program, thirteen VSU graduate students did their M.S. thesis research on these research topics. This included participation in their thesis experiments at major research facilities (the Alternating Gradient Synchrotron at Brookhaven National Laboratory and the Tri-University Meson Facility) where they worked with both their advisers and the research staff at these laboratories, and were

thus totally immersed in the research enterprise.

Future Work

Fortunately, this research group at Virginia State University has successfully solicited two research grants this past year, one from the Air Force Office of Scientific Research (AFOSR), the other from the Ballistic Missile Defense Organization (BMDO). The AFOSR grant supports studies of superconducting and magnetically-ordered materials with the μ SR and neutron-scattering techniques, thus providing a seamless transition from DoE to AFOSR support. The BMDO grant will support fabrication of novel nanoengineered materials by the use of mechanical milling, and will provide funds to bring Dr. A.S. Arrott (recently retired from Simon Fraser University) to VSU as a part-time Distinguished Senior Research Professor.

The problems that will be of primary scientific concern relative to the areas of research supported by the DoE appear to be (1) a survey of underdoped single crystals of high- T_c materials in the search for evidence for or against the SO(5) theory of superconductivity and antiferromagnetism, (2) measurements of penetration depths and searches for phase transitions such as 2D-3D in overdoped high- T_c materials; (Both of these studies should help pin down the pairing mechanism for high-temperature superconductivity.) (3) determination of the incommensurability gap in Cr and its alloys, to be studied with neutron scattering. New areas of research we hope to develop include the nanoengineered materials mentioned previously, plus studies of fatigue and adhesion in both magnetic and non-magnetic materials. We also hope, should funding become available, to organize a small theory group that will study various aspects of superconductivity and magnetic ordering.

Respectfully submitted,

Carey E. Stronach, Ph.D.
Director & Professor of Physics
September 30, 1997

Papers Published with Full or Partial US DOE Support

μ SR Measurement of the Fundamental Length Scales in the Vortex State of $\text{YBa}_2\text{Cu}_3\text{O}_{6.60}$

J.E. Sonier, R.F. Kiefl, J.H. Brewer, D.A. Bonn, S.R. Dunsiger, W.N. Hardy, R. Liang, W.A. MacFarlane, R.I. Miller, T.M. Riseman, D.R. Noakes, C.E. Stronach, M.F. White Jr.
Physical Review Letters, accepted for publication.

Magnetic Field Dependence of the London Penetration Depth in the Vortex State of $\text{YBa}_2\text{Cu}_3\text{O}_{6.95}$

J.E. Sonier, R.F. Kiefl, J.H. Brewer, D.A. Bonn, S.R. Dunsiger, W.N. Hardy, R. Liang, W.A. MacFarlane, T.M. Riseman, D.R. Noakes, C.E. Stronach
Physical Review B **55** (1997) 11789.

A Muon Spin Rotation Study of the Superconducting Condensate Density in High-Temperature Superconductors

Ch. Niedermayer, C. Bernhard, J.L. Tallon, G.V.M. Williams, J.I. Budnick, E.J. Ansaldo, C.E. Stronach, D.R. Noakes, C. Bucci, R. DeRenzi, G. Guidi
Hyperfine Interactions **105** (1997) 139.

Texture Effect on Vortex-State Transverse-Field μ^+ SR in Bi-2223 High- T_c Materials

R.I. Grynszpan, P.L. Langlois, D.R. Noakes, C.E. Stronach, M.M. Granderson, E.J. Ansaldo, J.R. Brownstein, A.J. Hill, T.J. Bastow
Hyperfine Interactions **105** (1997) 95.

Magnetic Penetration Depth and Condensate Density of Cuprate High- T_c Superconductors Determined by Muon-Spin Rotation Experiments

C. Bernhard, Ch. Niedermayer, U. Binniger, A. Hofer, Ch. Wenger, J.L. Tallon, G.V.M. Williams, E.J. Ansaldo, J.I. Budnick, C.E. Stronach, D.R. Noakes, M.-A. Blankson-Mills
Physical Review B **52** (1995) 10488.

Anisotropy and Dimensional Crossover of the Vortex State in $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$ Crystals

C. Bernhard, C. Wenger, D.M. Pooke, J.L. Tallon, Y. Kotaka, K. Kishio, D.R. Noakes, C.E. Stronach, T. Sembiring, E.J. Ansaldo, Ch. Niedermayer
Physical Review B **52** (1995) R7050.

Moving Maglev Underground

C. E. Stronach
Superconductor Industry **8** (2) (1995) 6.

μ^+ SR Study of the Effect of Zn Substitution on Magnetism in $\text{YBa}_2\text{Cu}_3\text{O}_x$

P. Mendels, H. Alloul, J.H. Brewer, G.D. Morris, T.L. Duty, S. Johnston, E.J. Ansaldo, G. Collin, J.F. Marucco, C. Niedermayer, D.R. Noakes, C.E. Stronach
Physical Review B **49** (1994) 10035.

μ^+ SR Study of Zn Substitution in $\text{YBa}_2\text{Cu}_3\text{O}_x$: Is Hole Dynamics Affected?

P. Mendels, J.H. Brewer, H. Alloul, E.J. Ansaldo, D.R. Noakes, C. Niedermayer, G. Collin, J.F. Marucco, C.E. Stronach, G.D. Morris, T.L. Duty, S. Johnston
Hyperfine Interactions **86** (1994) 577.

Penetration Depths and Pinning in (BiPb)-2212 and (TlPb)-1212 - Universal Correlations Revisited

E.J. Ansaldo, J.J. Boyle, C. Niedermayer, H. Glückler, J.L. Tallon, A. Mawdsley, C.E. Stronach, D.R. Noakes, R.S. Cary, M.R. Davis, G.D. Morris
Hyperfine Interactions **86** (1994) 505.

Evidence for Endohedral Muonium in K_xC_{60} and Consequences for Electronic Structure

R.F. Kiefl, T.L. Duty, J.W. Schneider, A. MacFarlane, K. Chow, J.W. Elzey, P. Mendels, G.D. Morris, J.H. Brewer, E.J. Ansaldo, C. Niedermayer, D.R. Noakes, C.E. Stronach, B. Hitti, J.E. Fischer
Physical Review Letters **69** (1992) 2005.

Observation of Magnetic Order in the Double-Layer System $La_2MCu_2O_{6+\delta}$ ($M = Ca, Sr$)

E.J. Ansaldo, C. Niedermayer, H. Glückler, C.E. Stronach, T.M. Riseman, R.S. Cary, D.R. Noakes, X. Obradors, A. Fuertes, J.M. Navarro, P. Gomez, N. Casañ, B. Martinez, F. Perez, J. Rodriguez-Carvajal, K. Chow
Physical Review B **46** (1992) 3084.

Formation of Muonium and a Muonic Radical in Fullerene

E.J. Ansaldo, J.J. Boyle, C. Niedermayer, G.D. Morris, J.H. Brewer, C.E. Stronach, R.S. Cary
Physics and Chemistry of Finite Systems: From Clusters to Crystals, Vol. II, P. Jena et al., eds., Kluwer Academic Publishers (1992) 1305.

Impurity Species Dependence of Zero-Field Muon Spin Rotation in Chromium Alloys

D.R. Noakes, E. Fawcett, E.J. Ansaldo, C. Niedermayer, C.E. Stronach
Journal of Magnetism and Magnetic Materials **114** (1992) 176.

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E.J. Ansaldo, J.J. Boyle, C. Niedermayer, G.D. Morris, J.H. Brewer, C.E. Stronach, R.S. Cary
Zeitschrift für Physik B **86** (1992) 317.

Superconductivity and Magnetic Order in Superoxygenated $La_2MCu_2O_{6+\delta}$

E.J. Ansaldo, C. Niedermayer, H. Glückler, C.E. Stronach, T.M. Riseman, R.S. Cary, D.R. Noakes, X. Obradors, A. Fuertes, J.M. Navarro, P. Gomez, N. Casañ, B. Martinez, F. Perez, J. Rodriguez-Carvajal, K. Chow
Physica C **185-189** (1991) 1213.

Muonium in Fullerite

E.J. Ansaldo, C. Niedermayer, C.E. Stronach
Nature **353** (1991) 121.

Site of the Positive Muon in $YBa_2Cu_3O_7$

J.H. Brewer, R.F. Kiefl, J.F. Carolan, P. Dosanjh, W.N. Hardy, S.R. Kreitzman, Q. Li, T.M. Riseman, P. Schlegler, H. Zhou, E.J. Ansaldo, D.R. Noakes, L.P. Le, G.M. Luke, Y.J. Uemura, K. Hepburn-Wiley, C.E. Stronach
Hyperfine Interactions **63** (1990) 177.

Magnetism in Electron-Doped Copper Oxides

G.M. Luke, L.P. Le, B.J. Sternlieb, Y.J. Uemura, J.H. Brewer, R. Kadono, R.F. Kiefl, S.R. Kreitzman, T.M. Riseman, C.E. Stronach, M.R. Davis, S. Uchida, H. Takagi, Y. Tokura, Y. Hidaka, T. Murakami, E.A. Early, J.T. Markert, M.B. Maple, C.L. Seaman
Hyperfine Interactions **63** (1990) 311.

The Superconducting Properties of $\text{YBa}_2(\text{Cu}_{1-x}\text{M}_x)_3\text{O}_7$ for $\text{M} = \text{Zn}$ and Ni

W.J. Kossler, X.H. Yu, A. Greer, H.E. Schone, C.E. Stronach, M.R. Davis, R.S. Cary, J.E. Crow, W.F. Lankford, J. Oostens
Hyperfine Interactions 63 (1990) 81.

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W.J. Kossler, X.H. Yu, A. Greer, H.E. Schone, C.E. Stronach, M.R. Davis, R.S. Cary, W.F. Lankford, A.R. Moodenbaugh, J. Oostens
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M.R. Davis, C.E. Stronach, R.S. Cary, W.J. Kossler, X.H. Yu, H.E. Schone, W.F. Lankford, A.R. Moodenbaugh, J. Oostens, P. Boolchand
Hyperfine Interactions 63 (1990) 305.

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G.M. Luke, L.P. Le, B.J. Sternlieb, Y.J. Uemura, J.H. Brewer, R. Kadono, R.F. Kiefl, S.R. Kreitzman, T.M. Riseman, C.E. Stronach, M.R. Davis, S. Uchida, H. Takagi, Y. Tokura, Y. Hidaka, T. Murakami, J. Gopalakrishnan, A.W. Sleight, M.A. Subramanian, E.A. Early, J.T. Markert, M.B. Maple, C.L. Seaman.
Physical Review B 42 (1990) 7981.

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Universal Correlation between T_c and n/m^* (Carrier Density over Effective Mass) in High- T_c Cuprate Superconductors

Y.J. Uemura, G.M. Luke, B.J. Sternlieb, J.H. Brewer, J.F. Carolan, W.N. Hardy, R. Kadono, J.R. Kempton, R.F. Kiefl, S.R. Kreitzman, P. Mulhern, T.M. Riseman, D.L. Williams, B.X. Yang, S. Uchida, H. Takagi, J. Gopalakrishnan, A.W. Sleight, M.A. Subramanian, C.L. Chien, M.Z. Cieplak, Gang Xiao, V.Y. Lee, B.W. Statt, C.E. Stronach, W.J. Kossler, X.H. Yu
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μ^+ SR Studies on High- T_c Superconductivity

Y.J. Uemura, B.J. Sternlieb, D.E. Cox, V.J. Emery, A. Moodenbaugh, M. Suenaga, J.H. Brewer, J.F. Carolan, W. Hardy, R. Kadono, J.R. Kempton, R.F. Kiefl, S.R. Kreitzman, G.M. Luke, T. Riseman, D.L. Williams, B.X. Yang, W.J. Kossler, X.H. Yu, H. Schone, C.E. Stronach, J. Gopalakrishnan, M.A. Subramanian, A.W. Sleight, H. Hart, K.W. Lay, H. Takagi, S. Uchida, Y. Hidaka, T. Murakami, S. Etemad, D. Keane, V. Lee, J.B. Torrance, D.C. Johnston
Journal de Physique 49, C-8 (1988) 2087.

Absence of Magnetic Order in (Ba,K)BiO₃

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Additional Publications

Since the submission of the final report for this grant, the following papers have been published by the VSU investigators supported by this program, with their collaborators from other institutions:

μ SR measurement of the fundamental length scales in the vortex state of $\text{YBa}_2\text{Cu}_3\text{O}_{6.60}$

J.E. Sonier, J.H. Brewer, R.F. Kiefl, D.A. Bonn, S.R. Dunsiger, W.N. Hardy, R. Liang, W.A. MacFarlane, R.I. Miller, T.M. Riseman, **D.R. Noakes**, C.E. Stronach and M.F. White, Jr.
Phys. Rev. Lett **79**, 2875 (1997).

Anomalous zero-field muon spin relaxation in highly disordered magnets

D.R. Noakes and G.M. Kalvius
Phys. Rev. B Brief Reports **56**, 2352 (1997).

Invited paper: Spin-density-wave antiferromagnetism in the chromium system II: critical and high-temperature fluctuations, spin-glass behavior in Cr(Mn)

E. Fawcett, P.C. de Camargo, V.Y. Galkin and **D.R. Noakes**
Proc. Int. Conf. Physics of Transition Metals 1996, Physica B **237-238**, 425 (1997).

Nature of the triple point in chromium alloys: mode-softening of the incommensurate spin density wave.

D.R. Noakes, E. Fawcett, B.J. Sternlieb, G. Shirane and J. Jankowska
Proc. Int. Conf. Neutron Scattering 1997, Physica B, accepted for publication.