RARE-EARTH INFORMATION CENTER NEWS

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HEBREW UNIVERSITY Rare Earth Group. Pictured in the front row from left are A. Langer, I. J. Brandstadter, B. Barnett, E. Greenberg, N. Lieblich, L. Boehm, R. Reisfeld, M. BenAruch and D. Jacobson. In the back row from left are D. Lubelchick, S. Kraus, A. Bornstein, H. Mack, J. Hormodaly, S. Nathanson and Y. Eckstein.

RE Optical Properties Studied—

Hebrew University Combines R & D

Rare earth studies at the Hebrew University in Jerusalem, under the direction of Dr. R. Reisfeld, are concerned mainly with the optical properties of the rare earths. The group, part of the Department of Inorganic and Analytical Chemistry at the University, carries out both basic research and developmental programs.

Ligand field theory, used for the interpretation of covalent bonding between rare earth ions and oxygen ions in glasses, can be extended as a general model of bonding in glass. Calculations are made of radiative and nonradiative electronic transition probabilities of rare earths in glasses and other media, and the influence of the host matrix on these transitions is studied. These studies are now being extended to systems of biological importance such as ATP (adenosine triphosphate).

The microstructures of glasses are investigated by defining the site symmetries from the number of lines in the emission or absorption spectra into which the free ion levels of the rare earths are split. Crystal field parameters are also deduced from the oscillator strengths of the *f-f* transitions of the rare earths in glasses. The luminescences of the rare earth-doped glasses are studied by means of cathode ray excitation. The practical application of this investigation is the possible study of surface phenomena in glasses and the preparation of glass phosphors for color television and communication purposes.

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Rare Earths In the News

AMORPHOUS BUBBLES

IBM scientists have reported the first observance of magnetic bubbles in amorphous films of gadolinium-cobalt and gadolinium-iron. These films are easier to make and less expensive than the crystalline materials previously developed for use in computer circuits, according to IBM.

RE's COMBAT NO_x

In preliminary tests, Bell Laboratories scientists have found that lanthanum lead manganite reduces most or all of the nitrogen oxides present in auto exhaust to nitrogen. Bell claims that the RE material is

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Rare Earths in the News
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as effective at high temperatures as any other available catalyst and is even more effective at low temperatures. This is the same compound that last summer was reported to convert CO to CO_2, see *RIC News,* **VII** [3] 3 (1972).

DIAGNOSTIC LOCATOR

Ytterbium-169 has been found to be a highly effective cancer seeker when injected into the veins of cancer patients, according to Prof. K. Hisata of Kanazawa University in Japan. The isotope collects only in cancerous tissues where it can be detected by the characteristic gamma rays it emits, says Prof. Hisata. Moreover, the technique is effective in pursuing the spread of cancer.

RE X-RAY PHOSPHOR

Dr. V. A. Fassel and A. P. D'Silva at the AEC's Ames Laboratory have developed an yttrium-gadolinium phosphate phosphor containing a small amount of terbium which gives intense violet-blue fluorescence under x-ray irradiation. Terbium shifts the spectral emission into the blue region that matches the x-ray image response characteristic of blue-sensitive x-ray film used widely in industry and medicine. By substituting gadolinium-157 for natural gadolinium, the phosphor's neutron absorption characteristics are enhanced, permitting the phosphor to be used in an intensifier screen for neutron radiography.

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Contributors at All Time High

With the addition of ten more contributors since the last issue of *RIC News* went to press, the total number of firms supporting the Center now stands at a record high of 38. We at RIC are extremely gratified that our efforts are so enthusiastically supported by the industry. Our contributors, too, can take justifiable pride in their efforts to provide the services their funding makes possible for the entire rare earth community.

Listed below are the ten additional contributors for Fiscal Year 1973; the number in parenthesis behind each contributor's name indicates the total number of years that firm has helped fund RIC.

British Flint & Cerium Manufactors, England (1)
Companhia Industrial Fluminense, Brazil (1)
Foote Mineral Co., U.S.A. (1)
General Electric Co., Magnetic Materials Product Section, U.S.A. (1)
General Electric Co., Research and Development Center, U.S.A. (1)
GTE Laboratories, Inc., U.S.A. (1)
Lim Fong Seng Sdn. Bhd., Malaysia (2)
Nippon Yttrium Co., Ltd., Japan (3)
Wako Bussan Co., Ltd., Japan (4)
Westinghouse Electric Corp., U.S.A. (1)

"This sample came from a parking place. I guess that makes it one of the rare earths."

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Magnetism School

Up-dated papers on the magnetism of rare earth materials originally presented at the Third Simon Fraser University Summer School on Solid State Physics held at Alta Lake, B. C., Canada, Aug. 24 - Sept. 5, 1970, have been published in *CRC Crit. Rev. Solid State Sci.* 3, [1] and [2] 83-241 (1972).

B. R. Cooper, [1] pp. 83-129, reviews those aspects of rare earth magnetism in which the crystal lattice affects the nature of the magnetic behavior through large orbital contributions. Topics covered include magnetic ordering, crystal-field theory, lattice distortion effects and transitions between magnetic structures in the heavy rare earths. Cooper also treats the theoretical and experimental behavior of induced magnetic systems, such as dhcp Pr, fcc Pr and Pr-Th alloys, in which the relative strength of the crystal field and exchange interactions determine whether any magnetic ordering occurs.

The theory of magnetic semiconductors, their optical properties and *s-f* interactions are discussed by T. Kasuya, [2] pp. 131-165. His review includes an explanation of one-electron energy spectra and of the collective energy spectrum in magnetic semiconductors. The anomalous red shift in the magnetic exciton in EuF_2 and europium chalcogenides and the effect of the *s-f* interaction on the transport properties in magnetic semiconductors are also presented.

A. R. Mackintosh, [2] pp. 166-188, in a discussion of the electrons and spin waves in heavy rare earth metals reviews the results of energy band calculations with an emphasis on the manner in which the special characteristics of the atomic *s-p, d* and *f* electrons are reflected in the electronic and magnetic properties of the metals. Experimental evidence for the conduction band structure, Fermi surface and 4*f* electrons is also presented.

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Lanthanide Cyanides

The preparation of the first anhydrous lanthanide cyanides was reported by I. J. McColm and S. Thompson, *J. Inorg. Nucl. Chem.* 34, 3801-3807 (1972).

The compounds were obtained by a precipitation reaction between NH_4CN and a liquid ammonia solution of the lanthanide metals. The liquid ammonia-lanthanide solution was prepared by electrolysis. The cyanides were finely divided and difficult to handle or investigate. Previous attempts by other workers to prepare the cyanides in aqueous media resulted only in the precipitation of the metal hydroxides.

McColm and Thompson report analytical, infrared, x-ray and magnetic moment data for some of the cyanides and Mössbauer spectra for the europous and europic compounds.

Hebrew University

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Investigations of energy transfer phenomena between rare earths and from mercury-like ions to rare earth ions in glasses are made. From the transfer rates, the role of glass matrix is deduced. The results obtained in glasses are extended to biological systems in which rare earths can serve as indicators of energy transfer. The role of glass phonons on energy transfer is studied and the suitability of glasses for new lasers is predicted.

Nondestructive analytical methods for determining rare earths are developed by making use of their fluorescent characteristics. Rare earth-doped glass standards for fluorescent measurements are developed.

Cooperation exists between this group and other institutions in Israel such as the Israel Ceramic Institute (Dr. Ish Shalom), Soreq Nuclear Research Center (Dr. Barnett), and Nuclear Research Center Negev (Mr. Brandstadter). There is also international cooperation with the U.S. National Bureau of Standards (Drs. Menis and Velapoldi) and with RCA (Dr. Larach).

Magnetism School

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In the last paper in the series P. Wachter, [2] pp. 189-241, reviews the optical, electrical and magnetic properties of the europium chalcogenides and the rare earth pnictides. The absorption spectra of free RE ions, those diluted in a host matrix, and the spectra of RE compounds are explained. Wachter also discusses the influence of magnetic order on the optical spectra of solids and the luminescence of europium chalcogenides.

LOST LASER

A controversy has developed over the reported production of the first x-ray laser, *RIC News* VII [4] 4 (1972). In the original report a University of Utah team claimed they obtained coherent x-rays by focusing a Nd laser on a thin layer of gelatin containing a solution of $CuSO_4$. Photographic film was used to detect the x-rays.

The spots observed on the film, according to T. A. Boster from the University of California's Lawrence Livermore Laboratory, were not caused by x-rays but were merely the result of an electrostatic effect observed when pieces of photographic film are rubbed together or subjected to impacts or shock waves. Boster's results were to be published in the February 1973 issue of *Applied Optics.*

Both sides of the controversy were presented in *C & E News* 51 [4] 27-28 (Jan. 22, 1973).

THERMAL CONDUCTIVITY

Recommended reference values for the thermal conductivity of all of the elements have been compiled by C. Y. Ho, R. W. Powell and P. E. Liley, *J. Phys. Chem. Ref. Data* 1, 279-421 (1972). The values are the result of critical evaluation, analysis and synthesis of all available data. Values were estimated for those elements for which data were not available. The results are presented in both graphical and tabular form over the full temperature range of experimental data or for which reliable extrapolations or estimations could be made.

The compilation also includes summary graphs of the thermal conductivities of each group of elements in the periodic table and a summary of the general procedures used for the estimation of data.

MEETING

PRELIMINARY PROGRAM

The Europhysics Study Conference committee has released the preliminary program for the conference which is to be held Aug. 29–Sept. 1, 1973, at Elsinore, Denmark (see *RIC News,* VII [4] 3 (1972).

ELECTRONIC STRUCTURES: The Electronic Structures of the Rare Earth Metals and Actinides, **A. J. Freeman**; Photoemission Studies of Rare Earth Metals, **Y. Baer**; Renormalized Atom Theory of Rare Earth Metals, **R. E. Watson.**

VALENCE CHANGES: Theory of Valence Transitions, **L. M. Falicov**; The Electronic Properties of Ce, **B. Coqblin**; Metal-Insulator Transitions in Sm Monochalcogenides, **D. B. McWhan.**

MAGNETIC STRUCTURES AND MAGNETIZATION: Magnetic Structures and Conduction Electron Spin Densities, **R. M. Moon**; Magnetic Form Factors in Rare Earth Metals and Compounds, **T. O. Brun**; High Field Magnetization of Rare Earth Metals, **L. W. Roeland.**

MAGNONS AND PHONONS: Magnon Dispersion Relations and Exchange in Rare Earth Metals, **R. M. Nicklow**; Phonons, Magnon-Phonon Interactions and Magnetic Anisotropy from Inelastic Neutron Scattering, **J. C. G. Houmann**; Magnetoelastic Effects and Elastic Constants, **J. Jensen.**

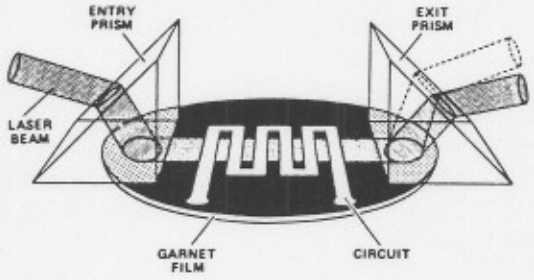
SINGLET GROUND STATES AND HYPERFINE INTERACTIONS: Magnetic Properties of Pr, **B. D. Rainford**; Singlet Ground States in Rare Earth Compounds, **R. J. Birgeneau**; Rare Earth Hyperfine Interactions, **B. Bleaney.**

DILUTE ALLOYS AND DOMAINS: Electron Spin Resonance in Dilute Rare Earth Alloys, **R. Orbach**, Superconductivity and Electron Scattering in Dilute La Alloys, **D. K. Finnemore**; Magnetic Domains in Rare Earth Metals, **T. Egami.**

SUMMARY AND DICUSSION: Theoretical, **R. J. Elliott**; Experimental, **A. R. Mackintosh.**

Applications for the conference, attendance is limited to 100 persons, should reach the committee before May 1, 1973; accepted applicants will be notified by about May 15. Registration fee for the conference has been set at $110.

GARNET SWITCH MODULATES LIGHT



A magnetically controlled switch which can modulate light has been developed by researchers at Bell Laboratories. The switch consists of a thin-film of single crystal yttrium-gallium-scandium-iron garnet in which the light is guided, and a tiny, serpentine-like electric circuit which imposes the required information on the light beam. The laser beam is guided into and out of the garnet by a prism at each end.

A magnetic field, created by passing an electric current through the circuit, causes the light beam in the garnet to change its polarization and the direction in which the light is refracted out of the garnet by the prism. Information can be coded on the light beam by switching the beam in or out of its original path in a controlled pattern of light pulses.

With the development of this light switch it may be possible to use laser beams to replace wire conductors, coaxial cables, and microwaves in future communications systems.

Soviet Collection

In the past few months RIC has received several Russian books dealing with rare earths. They are: a book dedicated to E. M. Savitskii on his 60th birthday, *Physicochemistry of Rare Metals*, I. V. Tananaev, ed. (Nauka, Moscow, 1972); *Rare Earth Metals and Alloys* E. M. Savitskii and V. F. Terekhova, eds. (Nauka, Moscow, 1971); *Handbook of Rare Earth Metals and Their Refractory Compounds* by S. P. Gordienko, B. V. Fenochka and V. V. Fesenko (Naukova Dumka, Kiev, 1971); *Lanthanides in Minerals* by D. A. Mineev (Nedra, Moscow, 1969); *Hydrothermal Occurence of Rare Earth Fluorocarbonates* by A. P. Khomyakov and E. I. Semenov (Nauka, Moscow, 1971); and *Electronic Structure and Physical Properties of the Solid State, parts I and II*, G. V. Samsonov, M. P. Arbuzov, V. S. Neshpor, I. A. Podchernyaeva, V. S. Fomenko, eds. (Naukova Dumka, Kiev, 1972). We have been informed that the first three books are to be translated into English. *When the English versions are issued, reviews of the books and information concerning their availability will be published.*

Atomic Spectra Bibliography

A bibliography of atomic energy levels and spectra from July 1968 through June 1971 has been published by L. Hagen and W. C. Martin, *U.S. Nat. Bur. Stand. Spec. Publ.* 363 (June 1972).

The bibliography contains 1100 references classified by subject for individual atoms and ions, including rare earths. The subjects indexed include energy levels, classified lines, wavelengths, Zeeman effect, Stark effect, hyperfine structures, isotope shifts and ionization potentials. The publication also contains an author index.

RE

The book, *Magnetic Properties of Rare Earth Metals*, edited by R. J. Elliott, summarizes the vast amount of information that has been published by many scientists from all corners of the earth in the past 10 years (some data, however, go back to the 1950's) on the magnetic behavior of these metals and their alloys. This was accomplished by contributions from nine experts dealing with seven aspects of rare earth magnetism, both experimental and theoretical.

A brief general introduction by the editor sets the tone for the rest of this volume. The remaining chapters deal with phenomenological theory of magnetic ordering by B. R. Cooper; magnetic structures by W. C. Koehler, bulk magnetic properties by J. J. Rhyne; spin waves by A. R. Mackintosh and H. Bjerrum-Møller; band structures, indirect exchange and magnetic ordering by A. J. Freeman; transport properties by S. Legvold; and hyperfine interactions by B. Bleaney.

Although the main emphasis of this book is on the metals themselves, some information is included on a selected number of alloys, especially the intra rare earth alloys. For anyone directly or indirectly involved with the magnetic bahavior of rare earth metals and alloys, this outstanding book will prove to be a valuable addition to his bookshelf. This 425 page book is available for $28.00 from Plenum Publishing Company.

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