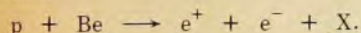


search & discovery

New particles excite experimenters and puzzle theorists

The world of high-energy physics has been set afire by the discovery of a new particle with very narrow width at 3.1 GeV. Experimentalists everywhere have rushed to their laboratories to try to measure some of the properties of the new particle. Already a second particle has been found at 3.695 GeV by one of the two groups that discovered the first particle. Theorists are consulting in corridors and in hastily summoned seminars to discuss possible interpretations of the discoveries. Some are calling the events "the greatest thing since strange particles."

Although the theoretical interpretations are very much up in the air, the experimental evidence for the new particle at 3.1 GeV is on very solid ground; it has been seen to date at three different laboratories and in several different decay modes. The first two observations came nearly simultaneously from opposite ends of the country. An MIT group¹ found it as a peak in the mass spectrum of electron pairs from the reaction



Their experiment was conducted at the Alternating Gradient Synchrotron at Brookhaven National Laboratory. This group was headed by Samuel Ting in close collaboration with Ulrich J. Becker and Min Chen. A SLAC-Lawrence Berkeley Laboratory/University of California collaboration encountered the new particle as an enhancement in the hadronic cross section from electron-positron collisions. They subsequently found the second particle² at



The two groups who found the new particle. At left is part of the MIT group at BNL. Standing (l-r) are: Samuel Ting, Garey Krey, Y. Y. Lee, Peter Biggs, Paul Goldhagen and Bruce Bailey. Seated (l-r) are: Ingrid Schulz, Joseph Leong and Sau Lan Wu. Members of the second group are (l-r) Martin Perl and Burton Richter of SLAC and Gerson Goldhaber of LBL/UC.

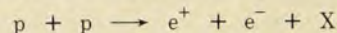


3.695 GeV. Their experiment was conducted at SLAC's storage rings, SPEAR. This collaboration is composed of two groups from SLAC, one headed by Burton Richter and the other by Martin Perl, and two groups from LBL/UC, one under Gerson Goldhaber and George Trilling and the other under William Chinowsky.

After learning of the discovery of the first particle from the MIT group and later from the SLAC-LBL/UC group, a group at ADONE, the storage rings at

Frascati, Italy, looked for and found the same narrow resonance in the same energy region.³ The MIT group has proposed that the new particle be called J , while the California team has suggested the names $\psi(3105)$ and $\psi(3695)$ for its two finds.

How was it found? The MIT group had been studying the reaction



to search for new particles that decay into $\mu^+ \mu^-$ or into $e^+ e^-$ and to investi-

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Superconductor operates in magnetic fields above 500 kG

A compound of lead, molybdenum and sulfur, $Pb_{1.0}Mo_{0.5}S_6$, has remained superconducting in a 510-kilogauss magnetic field at liquid-helium temperature, 4.2 K. This is the highest upper critical field H_{c2} (4.2 K) yet reported for a superconductor, and the predicted value for $H_{c2}(0)$ is 600 kG. Materials that remain superconducting at high magnetic fields could be formed into powerful, lightweight magnets if they can support high current density and are sufficiently strong to withstand the resulting forces. Simon Foner, Edward

J. McNiff Jr and Edwin Alexander of the Francis Bitter National Magnet Laboratory, Massachusetts Institute of Technology, described the high-field measurements at the recent Applied Superconductivity Conference in Oak Brook, Illinois (30 September-2 October) and in the 23 September issue of *Physics Letters*.

The ternary molybdenum sulfides were first synthesized¹ in 1971 by R. Chevrel, M. Sergent and J. Prigent of the Conseil National de Recherches Scientifiques in Rennes, France.

Bernd Matthias, Massimo Marezio, Ernest Corenzwit, Ann Cooper and Hartmuth Barz (Bell Telephone Laboratories and the University of California, La Jolla) shortly thereafter discovered² that many of these compounds, including the lead molybdenum sulfides, were superconducting. They reported a transition temperature T_c of 14.4 K for $Pb_1Mo_0.5S_8$. (Matthias tells us this has now been raised to 15.2 K.)

R. Odermatt, Ø. Fischer, H. Jones and G. Bongi at the University of Geneva, Switzerland subsequently tested³

several of the ternary compounds in pulsed magnetic fields up to 350 kG and steady fields up to 50 kG and extrapolated to higher fields. Some of their extrapolations (notably that for $\text{Pb}_{0.9}\text{Mo}_{0.1}\text{S}_6$) appear compatible with the subsequent measurements at the National Magnet Lab, whereas others (for tin-aluminum compounds) do not.

At the National Magnet Lab measurements were made over a wide range of applied fields—pulsed fields up to about 500 kG and steady fields of over 200 kG—and the higher-field superconductors were found by concentrating on the lead ternary compounds. For the best lead ternary compound, $\text{Pb}_{1.0}\text{Mo}_{0.1}\text{S}_6$, the pulsed magnetic field was as high as 495 kG; at this field value the superconducting-normal transition for the material was not yet complete and the experimenters estimate, from the behavior of other lead compounds with slightly lower values of T_c , that the transition occurs slightly above 510 kG at 4.2 K. They note that for the ternary compounds, their values of H_{c2} (4.2 K) appear to agree with predicted values of $H_{c2}(T)$ that are calculated assuming a type-2 superconductor with no paramagnetic limiting. Using this assumption, they predict that $H_{c2}(0)$ is 600 kG. Foner comments that even higher values of H_{c2} may be expected because the National Magnet Lab group has indications that some of their material has a higher critical temperature than 14.4 K, and their data shows that H_{c2} is proportional to T_c for the lead compounds.

Odd behavior of giant quadrupole resonance

Intensive study of an isoscalar giant electric quadrupole resonance in nuclear spectra, stimulated by its apparent discovery several years ago at a position just below the well established giant dipole resonance, has produced a modified—and puzzling—picture of its behavior. Stanley Hanna of Stanford University summarized the current experimental status of the giant quadrupole resonance (GQR) at a conference on Nuclear Structure and Spectroscopy held in Amsterdam, 9–13 September.

Any giant multipole resonance should exhibit three properties: it should be a general feature of all nuclei, it should be localized in a fairly narrow region of the spectrum and its strength there should exhaust a considerable fraction of an appropriate sum rule. The earlier evidence for the GQR, from inelastic scattering of electrons, protons, He^3 nuclei and alpha particles, showed it to have these properties. (See *PHYSICS TODAY*, September 1973, page 18.) It was centered, at an energy of $63/A^{1/3}$, quite close to the position predicted theoreti-

Will the lead-molybdenum sulfide, or any of the other ternary compounds, be able to carry the high current density needed for a dc magnet? This question must be answered experimentally before the practical value of the alloy can be known. Myron Strongin (Brookhaven National Laboratory) points out to us that there is reason for some caution in estimating the prospects for high current density. From the Abrikosov relation we have

$$H_{c2} = (2)^{1/2} \kappa H_{c1}(\text{bulk})$$

where κ is the Ginzburg-Landau parameter and $H_{c1}(\text{bulk})$ is the bulk critical field. Because $H_{c1}(\text{bulk})$ increases with T_c , we would expect a comparable or lower value for this alloy than for Nb_3Sn , which has a higher T_c . The value of κ then must be extremely high, and a very large κ usually indicates lower ultimate values of the flux pinning forces, which could imply a small useful current density. For different reasons, namely those of stability, Matthias also doubts the value of these sulfides for any future magnet.

—MSR

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cally for an isoscalar quadrupole resonance. (The GDR is at $(70-80)/A^{1/3}$.)

However, the recent data have shown that the GQR becomes quite spread out for nuclei with mass number A less than 40. These experiments show that the electric quadrupole (E2) strength in the lighter nuclei, summed over all energies, appears to exceed the sum rule, most probably, asserts Hanna, because it consists of a mixture of isoscalar and isovector strengths.

This new picture of the GQR has been compiled by a variety of experiments. The heavier nuclei have been studied primarily by inelastic scattering of electrons, protons, He^3 nuclei, deuterons and alpha particles. Recently, a group at Texas A&M University did a study of inelastic alpha scattering on a number of nuclei from Pb^{208} down to N^{14} . Their data show a systematic broadening of the GQR until, at Al^{27} , it is completely absent from the spectrum.¹ One advantage of alpha-particle scattering is that it selectively excites the isoscalar strength.

Radiative-capture experiments have been important largely for studying the lighter nuclei. The radiative capture of

alpha particles was found to have great strength, accounting for 50% of the sum rule when combined with the strength in the bound states. The strength was considerably spread out below the position of the GQR observed in the heavier nuclei. These radiative alpha-capture studies were performed by groups at the Argonne National Laboratory,² at the Australian National University in Canberra,³ at the University of Washington⁴ and at Stanford.

Radiative capture experiments and their inverse have also been done with protons—both (p, γ) and (γ, p) . Studies with polarized protons done at Stanford⁵ have been particularly enlightening because they give unambiguous separation of the E2 from the E1 strengths. These data also fail to show any concentration of E2 strength in a narrow region and add to the evidence that the total observed E2 strength exceeds the sum rule.

No theoretical calculations have yet been carried out to account for the disappearance of the GQR in lighter nuclei. Meanwhile, as Hanna pointed out, experimentalists should continue efforts to measure more accurately the E2 strength, to locate all the strength and to determine the isospin and the decay modes.

—BGL

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New storage rings operate at DESY

DORIS—the electron storage ring facility at DESY (Deutsches Elektronen Synchrotron) in Hamburg—made her debut in early October and by now is supplying beams for two interaction regions. The director of the DESY Laboratory, Herwig F. Schopper, spoke to us about them during a recent visit to the US.

The unique feature of DORIS is that it consists of two rings; thus it can produce electron-electron as well as electron-positron collisions. However, this feature of DORIS will not be developed until later this year, estimates Schopper. The rings are elliptical, with a circumference of about 280 meters, and are situated one above the other, with the beams intersecting twice at a cross-