note, this apparent disagreement may be a result of thermal disequilibrium.

The original simple theory was borne out by many kinds of experiments (all done above the expected T_s) during the past decade. As recently as 1969, for example, some magnetic-susceptibility studies led to confidence in the prediction of a simple antiferromagnetic ordering transition at about 2.7 mK. There had, however, been other high-temperature work to suggest that the He^3 transition might be a little unusual. John Wheatley, Orest Symko and Richard Johnson (at La Jolla) had studied[5] diffusion constants, and their results have been qualitatively interpreted as indicating that something unusual might be going on. And several susceptibility measurements, most recently those of Douglas Osheroff, Richardson and David Lee,[6] have in fact found more magnetization in the solid than would be expected if the phase trasition occurred at 2.7 mK. Now that experimenters have reached sufficiently low temperatures, theorists will very likely receive a good deal more information to work with. —MSR

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US and Soviet claims for element 106

A new element—number 106—may have been synthesized nearly simultaneously by two groups, one from the Joint Institute for Nuclear Research in Dubna, USSR[1] and the other from the Lawrence Berkeley Laboratory and the Lawrence Livermore Laboratory.[2] The Dubna team mentioned their discovery at the Heavy Ion Conference in Nashville, Tennessee, last June, and the LBL–LLL group reported their findings to a meeting of the American Chemical Society in Atlantic City, N.J. in September.

The Dubna group consists of Yu. Ts. Oganessian, Yu. P. Tretyakov, A. J. Iljinov, A. G. Demin, A. A. Pleve, S. P. Tretyakova, V. M. Plotko, M. P. Ivanov, N. A. Danilov, Yu. S. Korotkin and Georgi N. Flerov. Members of the California team are Albert Ghiorso, Joachim N. Nitschke, Jose R. Alonso, Carol T. Alonso, Matti Nurmia and Glenn T. Seaborg of LBL, and Kenneth Hulet and Ronald W. Lougheed of LLL.

While Flerov, the leader of the Dubna group, was in the US last summer, he met with Ghiorso and Seaborg at Berkeley. Perhaps partly because of that meeting, neither side has proposed a name for the new element, as has been the case in the past when conflicting claims have arisen between these same two groups. The priority question will be settled by the International Union of Pure and Applied Chemistry, which has just formed a committee to rule on the claims over elements 104 and 105. Aside from the priority question, the findings of the two groups do not contradict one another because they pertain to different isotopes of element 106.

The synthesis of elements at the upper end of the periodic table is difficult because of the low production rates and the uncertainties regarding their nuclear properties. The experiments of the LBL–LLL and Dubna groups met this challenge in very different ways. The LBL–LLL group chose to identify the new element by producing an alpha emitter of the new element and by then establishing a direct genetic link between it and recognizable daughter and granddaughter nuclides. The Dubna team set out to produce an isotope of the new element that would decay by spontaneous fission. By studying the theoretical and experimental properties of neighboring elements, they extrapolate to predict the behavior of element 106. Dubna obtains a fission-active nuclide by accelerating much heavier ions than the standard carbon, oxygen and neon ions, and bombarding a relatively light target such as lead. Such a method holds perhaps the most hope for producing still heavier nuclei.

Experimental details. In the LBL–LLL experiment, the SuperHILAC accelerated O^{18} ions onto a Cf^{249} target. According to their report, element 106 was formed by the reaction Cf^{249} $(O^{18}$ $4n)_{106}X^{263}$. It then decayed by alpha emission to rutherfordium, which then decayed by alpha emission to nobelium, which in turn decayed by alpha emission. An elaborate detection system sought for correlations not only between the new element and its daughter but also between the daughter and granddaughter. The element thus identified had alpha energies of 9.06 and 9.25 MeV and a half life of 0.9 ± 0.2 sec. It was produced at a beam energy of 95 MeV but not at 91 or 100 MeV. The LBL–LLL team calculated a formation cross section of 0.3 nb. These observations are consistent with a calculated excitation function that predicts a half width of 7 MeV and a maximum cross section of 0.2 nb.

In the Dubna experiment, 280-MeV ions of Cr^{54} from the 310-cm cyclotron struck targets of Pb^{206}, Pb^{207} and Pb^{208}, in separate runs. Spontaneous fission activities were detected by means of foils exposed to a rotating target disk. The foils were etched and scanned with a microscope to detect the number of fission tracks and the half life of spontaneous fission activity. According to both Ghiorso and Lee Grodzins (MIT), the main difficulty in using spontaneous fission activity in new element research is that the nuclei of the new element are destroyed in the fission process without leaving a daughter nucleus. Thus it is not possible to detect the atomic number and mass number of the original nucleus by means of a genetic link to a known nuclide.

In order to circumvent the problem, the Dubna group studied the excitation of compound nuclei formed when lead was bombarded with various projectiles. They found that the excitation energy is lowest when projectiles having a mass number in the range from 40 to 60 were used. Thus, the Russians feel that the compound nucleus created when Cr^{54} strikes a lead target is most likely to be formed in the ground state and is not likely to deexcite by emission of alphas or protons prior to the fission.

Next, by bombarding lead with Ar^{40}, the Dubna group studied fission activity they believed was caused by fermium isotopes formed with the emission of one, two, three and four neutrons. They found that the compound nucleus is most likely to emit two or three neutrons. Similar measurements were made on activities that, the Russians state, belong to element 104. Noting that a fission activity with a half life of 4 to 10 msec was formed when Cr^{54} struck Pb^{207} or Pb^{208} but not Pb^{206}, they extrapolated the above results to production of element 106 and concluded that isotope 259 was formed. The measured cross section was 1 nb for both Pb^{207} and Pb^{208} targets.

Of course, both experiments are subject to some criticism, the most basic centering around the Russian experiment. Because, in Grodzins's words, fission is "not a specific signature" of an element, the Dubna evidence is not direct but depends heavily on inferences. Grodzins feels the Dubna group has certainly found some new spontaneous fission activity but that further work is required to clarify its source.

Grodzins believes that the LBL–LLL

experiment could be wrong only if a series of unlucky coincidences had occurred. He commented that the evidence could be strengthened by studies with an O^{16} beam. Ghiorso himself was very confident of his group's results: he felt that production of element 106 was proved better than any other element in history. —BGL

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Silicon-monoxide maser

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tern from 18-cm OH masers. With the aid of Frank Lovas and Donald Johnson of the National Bureau of Standards, they tentatively identified the complex spectrum as the Doppler velocity shifting of the rotational $J = 2 \rightarrow 1$ transition of the first vibrational state ($v = 1$) of the SiO.

Subsequently, several sets of observations confirmed this analysis. The first was made by John Davis, Guy Blair and Howard Van Till of the University of Texas and Patrick Thaddeus of the Goddard Institute for Space Studies, who used the 16-foot antenna of the Millimeter Wave Observatory at the University of Texas. They detected a line in Orion near 129.3 GHz that could be the $J = 3 \rightarrow 2$, $v = 1$ transition in SiO.[2] Next, Thaddeus, John Mather (Goddard Institute for Space Studies), Davis and Blair used the same telescope to find lines at 43.1 GHz that would correspond to the $v = 1$, $J = 1 \rightarrow 0$ transition. These lines were sighted in both Orion and in the M-type star W Hya.[3]

In a survey of maser emission from the $v = 1$, $J = 2 \rightarrow 1$ transition of SiO, Kaifu, Buhl and Snyder of NRAO found that the only sources outside Orion were a number of late M-type variable stars, many of which have both OH and H_2O emission.[4] Buhl, Snyder, Lovas and Johnson have since observed the $v = 2$, $J = 1 \rightarrow 0$ transition and have failed to find the $J = 1 \rightarrow 0$ transition of either the third vibrational state or the ground state[5] (see figure). The missing lines place constraints on any models of pumping mechanisms.

Buhl and Snyder point out that the pumping of the observed maser lines requires excitation temperatures as high as 3520 K (for the second vibrational state). Red giants possess the required energy but interstellar clouds do not, in agreement with the observations. The problem is to explain how this tremendous amount of energy is transferred to the SiO molecules. Possible mechanisms have been proposed by theorists such as Charles Townes and Thomas R. Geballe of the University of California at Berkeley,[6] John Kwan (Institute for Advanced Studies) and Nicholas Scoville (Cal Tech)[7] and Mather and Marvin Litvak (Harvard) who described their model at the American Astronomical Society meeting at the University of Rochester in August. However, most agree that it is too early to comment on these models.

Thaddeus felt that the models of the SiO maser may prove to be more tractable than those of either the OH or H_2O masers; SiO has neither the chemical interactions of the OH molecule (because of its closed shell) nor the complicated rotational structure of the H_2O molecule. Townes further commented that we know the location of the SiO molecules better than we do that of OH or H_2O.

Applications. The new maser emissions may teach us something about the infrared stars from which they come. Buhl explained that the velocity spectra contain information about processes in the circumstellar envelope; the large Doppler shifts observed in all maser radiation indicate the very turbulent motion that occurs both as matter rushes outward in the death of a star and as it rushes inward in the formation of a star. Thaddeus pointed out that because the SiO maser is a point source it can reveal something about the small regions of space, especially when combined with optical observations of the same star. Further, each of the several observed transitions in SiO is an independent channel of information.

The maser lines may have some very important practical applications as well. Because they are point sources, the SiO masers can be used to test the millimeter-wave interferometers now being developed. Townes said that, in turn, these interferometers may better resolve the location of the maser sources and may possibly indicate how large the infrared stars are. Because the maser lines from the first vibrational state are so strong, Snyder feels they can be used to detect new infrared stars. Finally, the SiO masers can serve as point sources for the calibration of millimeter-wave telescopes, and Buhl and Snyder have already devised such a calibration technique for the NRAO dish.

Many astrophysicists are very excited at this first maser in the millimeter region and look forward to perhaps more maser discoveries at still shorter wavelengths. —BGL

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Bevalac makes a successful debut

On 1 August, physicists at the Lawrence Berkeley Laboratory successfully accelerated carbon-12 ions in the Bevalac. This new heavy-ion accelerator is a hybrid of existing accelerators; the SuperHILAC serves as the injector and the Bevatron provides the final acceleration (see PHYSICS TODAY, June, page 20). On the initial run, the carbon ions achieved an energy of 2.1 GeV per nucleon. Before the Bevalac, the most powerful heavy-ion accelerator was one in Canberra, Australia, with an energy of 20 MeV/nucleon.

Now in routine operation for nuclear physics and biomedical research, the Bevalac has accelerated neon as well as carbon, with intensities of 5×10^8 and 4×10^9 particles/pulse respectively, and, most recently, argon (2 GeV/nucleon). The Berkeley group will have to improve the vacuum system before still heavier ions can be accelerated.

Construction of the Bevalac began some eighteen months ago under the direction of Hermann Grunder. Albert Ghiorso, also of LBL, originally conceived the idea of pairing the two accelerators. Future plans include a time-sharing system, to be completed next spring, that will enable the SuperHILAC to be time-shared between the Bevalac and its own experimental program.

Stellarator moves from Culham to Wisconsin

The small stellarator, Proto-Cleo, which has been in use at Culham Laboratory (UK) for five years, has been moved to the University of Wisconsin, Madison. J. L. Shohet heads the NSF-sponsored move. Believed the largest fusion experiment to be transported, Proto-Cleo is the first complete fusion-experiment system to cross the Atlantic. Initial operation of the system in its new home is expected later this year.

With the coming of Proto-Cleo, the US will once again have a stellarator facility in operation. The large stellarator, Model C, was modified into the ST Tokamak at Princeton in 1969. □