electric repulsion from coming in contact with the bombarded nucleus.

Another interesting feature in collisions between charged particles and lighter nuclei is the remarkable resonance effects found for disintegrations caused by impacts of protons and α-particles. As in the case of selective effects of slow neutrons, such resonances must be ascribed to the coincidence of the sum of the energies of the incident particle and the original nucleus with a stationary state of the compound system corresponding to some quantized collective type of motion of all its constituent particles.[5] Especially in case of α-particle impacts, much information concerning the distribution of highly excited levels in lighter nuclei has been derived from such resonance effects. In contrast to the dense distribution of levels found in heavier nuclei, the spacing of the levels in this case is as large as several hundred thousand volts for an excitation considerably higher than ten million volts. This result can, however, be readily understood if one realizes that the lowest excited levels are farther away from each other for light nuclei than for heavier and that therefore the number of possible combinations of these levels in a given energy region is much smaller in the first case than in the second.

Not only the distances between the resonance levels, but also their half value breadths, are in general much larger in lighter nuclei than in heavier, indicating that the lifetime of the compound system is very much shorter in the former case than in the latter. This comes first of all from the circumstance that the resonances in heavy nuclei are found only for very slow particles, where the probability for escape is extremely small, so that the lifetime of the compound system is only limited by the probability of emission of electromagnetic radiation, whereas in lighter nuclei the lifetime is in general entirely determined by the possibility of releasing comparatively fast particles. Quite apart from this, we should, however, expect that the lifetime of a heavy nucleus—even if the nucleus were highly enough excited to emit fast particles—would be much longer than of a light nucleus on account of the lower temperature to be ascribed to a heavy nucleus than to a lighter one for a given excitation energy.

In fact, it would appear that quite simple considerations such as those here outlined enable us to account in a general way for the peculiar features of nuclear reactions initiated by collisions. Likewise it seems possible to explain the characteristic differences between the radiation properties of nuclei and those of atoms by means of similar considerations based also essentially on the extreme facility of energy exchange between the closely packed nuclear particles as compared to the approximately independent binding of each electron in the atom. The closer discussion of such problems will, however, claim more detailed considerations, which lie outside the scope of the present brief report.[6]

PHYSICS TEACHING IN THE SOUTH[1]

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PRESIDENT RICHTMYER of our association in his letter inviting a paper for this program suggested that it might be appropriate, on this the first joint meeting of the national group of physicists and the southeastern section, to discuss some of the peculiar problems of the South with reference to physics and physics teaching.

In suggesting the paper, I suspect, although he did not say so, that the president had in mind a fact, known to all of us, that from the view-point of per capita production the South has contributed and is contributing much less to scientific progress than the country as a whole, especially certain industrial sections. For instance, in a certain statistical[2] study made in 1927 of the geographical distribution as to place of birth of the one thousand starred scientists in "American Men of Science" the South Atlantic states showed a ratio (corrected for population) of one to two as compared with the Middle Atlantic states and one to three as compared with the New England states. It is significant, however, as showing progress that in 1903, twenty-four years earlier, a similar study shows an unfavorable ratio of one to eight of the South Atlantic to the New England states and one to five to

[5] Besides the total energy of the compound system also its spin and other symmetry properties may, as often pointed out, be of importance for the analysis of resonance phenomena. How such considerations can be brought into connection with the general picture of nuclear reactions here presented is discussed in a paper by F. Kalckar, I. R. Oppenheimer and R. Serber to appear shortly in *Physical Review*.

[1] A paper presented before the American Association of Physics Teachers, Chapel Hill, N. C., February 27, 1937. Somewhat condensed.

[6] A more comprehensive account of the development of the ideas here presented will be published shortly in the *Proceedings* of the Copenhagen Academy by Mr. F. Kalckar and the writer.

[2] See *American Journal of Sociology*, March, 1931.

the Middle Atlantic states. I suspect, however, that if these studies had been based on place where the work was done rather than the place of birth, the comparison would have been much more unfavorable to the South.

In trying to gather data for this discussion I sent out a questionnaire to about fifteen professors of physics, including all the state universities in the southeast and a few typical non-state-supported institutions. The idea was to get a cross-section of opinion rather than to make a comprehensive survey. At the time of writing this paper I had rather complete replies from twelve institutions as follows: Universities of Virginia, North Carolina, South Carolina, Georgia, Florida, Mississippi, Louisiana, Mississippi A. and M. College, Vanderbilt, Emory University and George Peabody College.

My first question was: What conditions (if any) are unique to the South (particularly your state) which demand a different type of physics course (either introductory or advanced) than for other sections of the country? The replies, most of them in general agreement, can be summarized as follows: High-school preparation, especially in mathematics, in general poorer than for many other sections; relatively little intellectual interest in scientific matters, especially physics, on the part of either the general public or high-school and college students. There was some reference to disadvantages of a "languid" climate. It was emphasized by several men, some of them northern men with wide experience with students from sections other than the South, that from the view-point of native ability there was nothing unique in the southern students, or, as one northern man expressed it, "Southern students are just as smart and eager as those from other sections."

As to languid climate, I do not believe that this is an important factor. Several recent studies, as for instance, those in Vance's "Human Geography of the South," have indicated that this factor, as related to intellectual achievement, has little weight. I might say that also as related to physical stamina and achievement there is little to the theory that the southern climate weakens achievement. Two facts can be cited here on this point. First, the remarkable stamina and endurance shown by southern soldiers in the Civil War; and, second, the rise to preeminence of southern athletes in football and other sports. When the southern teams were being consistently defeated in football many attributed this to climate influences, whereas it was really due to lack of interest in football in high schools and colleges.

As to the statements that in general southern students come into college more poorly prepared to do high-grade work than students from many other sections, there is no doubt as to the facts. This is especially true with reference to inadequate preparation in elementary science and mathematics.[3] This is to be expected, when we consider that even in the last twenty years, when the South has bettered its relative standing, the average per capita income of a southern citizen is about 50 per cent. of that of the country at large and the average expenditure of money, on either a per capita or per student basis, for school purposes from all government agencies is only about one third that of the national average. In the South we are not only poor but not educationally minded. Of course there are many exceptions to this meager support of schools, especially in the large cities and in a few states.

In this connection there is a vital point as related to the length of the secondary school period in some southern states as compared with other sections. In the state of Georgia about 75 per cent. of the freshmen come from eleven-year high schools, *i.e.,* seven years of elementary and four years of high-school work; and 25 per cent. come from twelve-year schools, *i.e.,* eight years of elementary and four years of high-school work. In contrast with this in the United States as a whole the twelve-year school organization predominates.[4] Recently, at the University of Georgia, Professor A. S. Edwards has made a study of the relative achievement in college of graduates of eleven- and twelve-year high schools. In both the entering classes of 1934 and 1935 there was a marked difference in favor of the twelve-year school graduate as judged from their freshman scholastic records and from their scores on a series of nation-wide comprehensive examinations set by the American Council on Education and taken by every entering Georgia freshman. On the American Council on Education general entrance examinations the twelve-year school graduates stood above the national average or 50 percentile rank, while the eleven-year school graduates stood at the 30 percentile rank; this brings the group as a whole only to a 35 percentile rank. It was shown in this study that this ranking was not a matter of chronological age, but in all probability resulted from the longer and better school training offered by the well-supported twelve-year schools from the large cities as contrasted with the poor training offered by poorly equipped small town and rural schools. This clearly indicates that standards in southern colleges could be raised if the twelve-year school organization predominated. As to high-school preparation of southern students in physics; from the limited data in hand it appears that perhaps 30 per cent. of entering freshmen present high-school physics units, whereas for the country as a whole the figure is above 50 per cent. The situation as to poor mathematics preparation is also bad in the South and likely to get worse, as there is a general movement in the southern schools to reduce the amount

[3] See Bryan, "Contemporary Georgia," chapter 2.
[4] See *High School Quarterly*, May, 1936.

of required mathematics. This movement is also very strong in other sections and should, in my opinion, be combatted by this association.

As to the statements of lack of intellectual interest in science and physics on the part of college students, this lack perhaps extends, regrettably, over the whole country, but is doubtless relatively greater in the southern regions. The South is predominantly an agricultural and not industrial section and, of course, where the applications of physics are constantly before the people there is a greater interest in both the applied and pure aspects of the science. On this point of industrial developments, there are many indications of a rapid shift of economic values in the South from agriculture to industry. For instance, statistics show[5] that there was 7.9 per cent. shift in this direction in the nation as a whole in 1931 but a 30 per cent. increase in the South Atlantic states. The figures refer to dollars added by manufacturing process as related to each dollar of gross agricultural income. A new industry of great promise in the South lies in the application of the scientific work of the southern chemist, Dr. Charles Herty, on the southern pine tree in its relation to paper manufacturing. Already about $10,000,000 is invested in this new industry and shortly, it is estimated, another $20,000,000 will be invested. This industry bids fair to rival the textile industry as the South's chief wealth producer. There is great promise also for southern agriculture and industry in the work of the American Chemurgic Council in their advocacy of research on the possible use of agricultural products in industry. Interest in the science of physics and its progress are closely related to industrial developments in a region and so if time permitted it might be of interest to trace the relative development of industry in the South and other regions since the founding of the nation.[6] Suffice it to say that in the early part of the last century before the large factory systems developed anywhere and in the handicraft stage of manufacturing history, it was by no means clear to contemporary observers that the South would not be an important, if not the most important manufacturing section of the country. At the critical period of the introduction of the factory system in this country the invention of the cotton gin and the supply of cheap slave labor lured the southerners away from industry to an agricultural civilization which, until the devastating effects of the Civil War destroyed it, made the South prosperous and contented. As so graphically described in the current "best-seller" novel, "Gone with the Wind," the war and its aftermath of reconstruction left the South with man power depleted and resources destroyed and faced with the vital problem of a mere existence. Only since the turn of the century have many sections recovered from this vital blow and begun to establish a saner agriculture than purely cotton growing and to develop industries and to pay adequate attention to elementary and higher education. As shown by Professor Odum,[7] of the University of North Carolina, and many others, there are many evidences that the South is on the eve of a larger industrial expansion. Since 1880 the South has increased its industrial development on a par with that of the country as a whole and has recently gained a little relatively in the industrial race.

It is significant to me in connection with the idea that there is a relation between industrial developments and interest in pure and applied science, that in the South as a whole, during the first third of the last century the South was holding its own with other sections not only in industry but also in interest in science and scientific work. This to my mind is proved in the recent book by Professor Johnson, of Virginia, on "Scientific Interests in the Old South." I have first-hand knowledge that his statements are correct with reference to the important position science had before the Civil War at the University of Georgia.[8] This knowledge comes from the old apparatus of the period at the university when I went to Athens, from the record of the minutes of the board of trustees as to the purchase of apparatus and from the eminent men filling the scientific chairs and their publications. In fact, I believe that physics equipment and instruction at that time in the university were on a par with all except a few of the large colleges in the country and even with them the comparison was not very unfavorable. Much to my regret, this is not true to-day, especially with reference to equipment and conditions of work. That scientific men of the old South were very active in science is indicated by the fact[9] that the first president of the American Association for the Advancement of Science was Professor W. B. Rogers, of the University of Virginia, and that in 1861, on the outbreak of the Civil War, the president was F. A. P. Barnard, of the University of Mississippi, the vice-president was Robert W. Gibbes, of South Carolina, and the secretary was John W. Mallet, of Alabama.

But to return to my questionnaire. My second question was: "What unusual organization of courses at your institution have you in effect to meet these unique conditions?"

In answer to this question two institutions, the Universities of Florida and Georgia, indicated not only an unusual organization of introductory science courses, but of the whole junior division curriculum. Both of

[5] See Bryan, "Contemporary Georgia," chapter 4.
[6] *Ibid.*
[7] See Odum's "Southeastern Regions," University of North Carolina Press.
[8] See University of Georgia Bulletin by R. P. Stephens on "Science in the South."
[9] See "Scientific Interests in the Old South," p. 196. D. Appleton-Century Company.

these institutions have followed the lead of the University of Minnesota and the University of Chicago in stressing the necessity of devoting the first two college years to rounding out a student's general education rather than encouraging early departmental specialization and have installed a rather rigid program of required courses of the survey type in the social sciences, the humanities, the biological sciences and the physical sciences. In both institutions about two thirds of all the work of the freshman and sophomore years in the general degrees is of the survey type. The syllabi of the courses in both institutions have been written specifically to meet typically southern conditions.

Returning to the questionnaire answers of the remaining ten institutions analyzed as to introductory course organization: Two, Kentucky and Louisiana State, have courses in physics of the non-laboratory survey type. The University of Kentucky reports their course as especially successful. Five institutions, Virginia, South Carolina, North Carolina, George Peabody and Emory, have no such survey type courses. Two, Vanderbilt and the University of Mississippi, are planning to install a survey type course next year. One, the Mississippi A. and M. College, reports that they have tried out a survey type course and abandoned it as inadequate for their conditions. George Peabody College reports having tried out several type survey courses and thinks that the type offered at the end of the senior division is the most successful. Emory University reports an elective course on "The History and Application of Physics to the Development of Civilization." Louisiana State mentions an interesting course, to meet regional needs, on geology physics and designed for geophysical prospectors for oil and gas.

In answer to a question as to any courses offered of a distinctive type not having any regional condition back of them, Emory and North Carolina mentioned courses in biophysics and x-ray technique. Florida mentioned an unusual organization of individual laboratory work, where very meager instruction is given in the manual and students left to their own devices. The University of Mississippi mentioned a successful practice of modifying their graduate courses each year to meet individual needs.

Thinking it might be of interest, I included among my questions one on the experience of various institutions in the South with the comprehensive tests on general physics administered by the American Council on Education. Of the six institutions who have used the test who reported an opinion as to their value, about half expressed an opinion that they were well worth while and the other three were doubtful as to their value. Typical comments are: "Tests are very worthwhile as a whole." "Tests have good suggestive value, pick out low-grade and high-grade students but do not check with other work as a whole." "Tests regiment students and professors too much."

Speaking of these tests, I think the fact is significant that a surprisingly large number of very high individual scores came from students from small colleges with poor equipment, some of them in the South. Equipment and highly trained technical men as teachers are of course very desirable, but native ability of students and the inspiration of a good teacher go a long way in offsetting handicaps of equipment and apparatus.

Thinking it might be of interest to know the relative records of southern students and those from other sections I obtained, through the courtesy of Dr. Beers, from the cooperative test service of the American Council on Education, the scores of 28 typical southern colleges on the general physics tests given last year. Running up a rough average, it develops that these 28 southern institutions show a percentile rank of about 33 based on all institutions in the country taking the test. Five of the 28 institutions showed scores above the 50 percentile rank; among these were the only two state universities for whom data were given. The percentiles of these institutions were 60 and 71, well up in the national average.

I included, also, to those institutions stating in their catalogues that they offer the Ph.D. degree, a question as to the number of such degrees granted by them in Physics—"(1) in the last fifteen years; (2) for all time?" Their replies are as follows:

	Last 15 years	All time
Virginia	25	26
Duke	7	7
North Carolina	12	12
Vanderbilt	None	1
Kentucky	1	1

I also included a question as to the prospects for an improved research program in the next five years as compared with the past five years. All except two of the institutions said that the prospects were good for better support for research and so better research. Louisiana State reported that with a new building, modernly equipped, their prospects for successful research in the next five years have been tremendously increased.

In conclusion, I wish to say that, although conditions as to physics teaching and research in the South are far from what they should be, there are many signs that the near future will see this section take its proper place in the scientific developments of the nation. Not the least of these signs is the organization of the new Southeastern Section of the American Physical Society and the large attendance of southern physicists at the meetings held so far, including this meeting.