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Upsilon particles at 9.4 and 10 GeV suggest new quark

Possible evidence for a new kind of quark has been reported by a group working at Fermilab. The team of experimenters from Columbia University, Fermilab and the State University of New York at Stony Brook observed a dimuon resonance, which they called upsilon, ϒ, at 9.4 GeV, by far the most massive resonance ever found. They reported their results at the European Physical Society Particle-Physics Conference held in Budapest in July. Since then the group reported evidence for ϒ′ at 10.0 GeV and preliminary indications for a third resonance at about 10.4 GeV. Both upsilon and upsilon prime have widths less than or equal to 200 MeV. These latest results were announced at the International Symposium on Lepton–Photon Interactions held in Hamburg late in August.

One promising interpretation of the upsilon is that it is a bound state of a new quark and its antiquark. This new quark, proposed by a number of theorists over the past couple of years, would join the ranks of the up, down, strange and charmed quarks.

The experiment was done by Steven W. Herb, David C. Hom, Leon M. Lederman, Johann C. Sens, H. David Snyder and John K. Yoh (Columbia), Jeffrey A. Appel, Bruce C. Brown, Charles N. Brown, Walter R. Innes, Koji Ueno and Taiji Yamanouchi (Fermilab), Al S. Ito,

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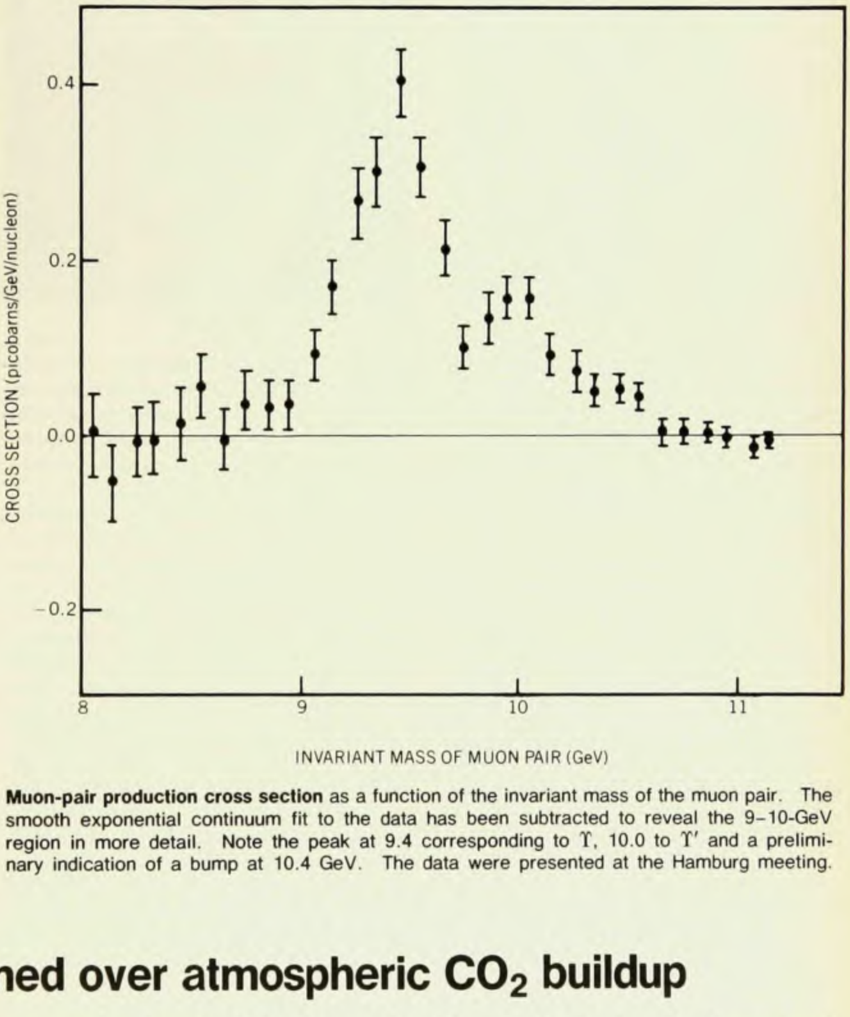

Muon-pair production cross section as a function of the invariant mass of the muon pair. The smooth exponential continuum fit to the data has been subtracted to reveal the 9–10-GeV region in more detail. Note the peak at 9.4 corresponding to ϒ, 10.0 to ϒ′ and a preliminary indication of a bump at 10.4 GeV. The data were presented at the Hamburg meeting.

NAS panel is concerned over atmospheric CO_2 buildup

A major buildup in atmospheric carbon dioxide could increase average global temperatures by as much as 6°C over the next century or two; this is the chief problem associated with continued worldwide dependence on fossil fuels, according to a panel on energy and climate convened by the National Academy of Sciences. The effects of such a climatic change, throwing the Earth's habitable surface back to conditions that prevailed in the Mesozoic Era, probably would include a shift of the agricultural and fishing zones toward the poles and destabilization of those semi-arid regions now considered marginal for human occupancy. The panel has recommended extensive further study of the energy-climate relationship, a tremendous interdisciplinary research effort and new institutions to deal with the problem. Physicists may be able to contribute to meeting the CO_2 threat through development of improved theoretical models and more precise determination of numerous measurements needed for accurate climatic predictions.

The 15-member Energy and Climate Panel, headed by Roger R. Revelle (University of California, San Diego, and Harvard University), was established after the NAS's Geophysics Research Board finished planning in 1974 for a series of studies on topics of geophysical interest. A Geophysics Study Committee, led by co-chairmen Philip H. Abelson (Carnegie Institution, Washington) and Thomas F. Malone (Holcomb Research Institute), supported Revelle's panel in its work.

Approaching the CO_2 problem. The panel began by considering three by-products of energy production and consumption—heat, particulate matter and gases—as potential sources for a significant degree of inadvertent modification of the Earth's over-all climate. The first two they soon dismissed as not irrevocably harmful on a global scale: Direct-heat release may be an important factor in local-climate determination, but for the foreseeable future manmade heat output will remain a tiny fraction of the heat produced by incoming solar radiation; the venting of particulate matter from manufacturing processes and other sources appears readily controllable from a technological standpoint, even if substantially increased. Revelle's panel focussed on carbon dioxide, produced in the combustion of fossil fuels, as the greatest potential menace to stability of the Earth's climate over the next few centuries; the so-called "greenhouse effect," in which atmospheric CO_2 traps solar heat by appearing transparent to the Sun's short-wave radiation (visible light) while strongly absorbing long-wave radiation (heat), could lead to a climatically significant rise in average temperatures near the Earth's surface—with particularly marked effects in high latitudes.

Revelle and his colleagues base their conclusions about the CO_2 threat on energy-consumption estimates and expectations of future energy sources for the next 200 years. The panel examined various models for the division of CO_2 among the oceans, the atmosphere and both living and dead organisms (the so-called "biosphere"); they found a range of agreement for these models that indicates a probable increase of four to eight times present levels of atmospheric CO_2 by the latter part of the twenty-second century. A review of models that associate increased CO_2 in the atmosphere with higher global temperatures suggests, according to the panel's report, that a corresponding increase of 2–3°C is to be anticipated for the average temperature at the Earth's surface for each doubling of the atmospheric CO_2 content. Increases in polar-region temperatures could be as much as three times greater. Such a change, the panel points out, might easily exceed all fluctuations in global temperature of the past few thousand years, including the most recent "ice age," which ended 10 000 years ago, when average midlatitude temperatures were 5–10°C lower than present norms.

Impact of a rising thermometer. An increase of 6°C in average global temperature could result in a climate comparable to that of the Mesozoic Era, the "Age of Reptiles" that ended 70–100 million years ago, the panelists warn. What are the possible consequences for human life? The panel notes that the near-surface waters of the oceans would be warmed, with the result that fish populations would tend to move toward the poles, the average sea level would rise (by about one meter for every 5°C increase in the temperature of the top 1000 meters of ocean water) and the Northwest and Northeast Passages would become open for shipping most of the year. "Agricultural belts," the panel concludes, "would be shifted by changing seasonal precipitation and temperature patterns. For some countries with marginal agriculture, the impact on food production could be severe." The panel finds it "impossible to forecast" what effect a general warming of the atmosphere and oceans might have

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on the Greenland and Antarctic ice caps. Abelson and Malone stress that "human capacity to perturb inadvertently the global environment has outstripped our ability to anticipate the nature and extent of the impact."

What can physicists do? There remain several conceptual problems to whose solution physicists may be able to contribute. The panel notes, for instance, that no feasible means to compensate for very large CO_2 emissions so as to prevent an atmospheric build-up or a rise in global temperature are known at present. One idea mentioned in the panel's report is to increase the Earth's albedo (reflectivity) so as to absorb less solar radiation; this could be done, in principle, by spreading large quantities of small reflecting platelets of latex over the ocean surface—however, the pile-up of billions of platelets on the world's beaches is an easily predicted and environmentally undesirable side-effect.

The panel states that it is not yet known whether climatic changes occur in fairly discrete, "steplike" shifts from one dynamically stable state to another, or if they take place by a gradual passage through a continuum of states. The steplike transition would be especially worrisome, because seemingly minor changes might bring on an abrupt change in climate. An even more suitable problem for the physicist is to determine what contributions to the world's energy needs can be expected from the various "renewable" (sometimes called "inexhaustible") resources.

More accurate measurements of a number of parameters in the energy-climate problem are needed. The variation with time of the ratio of C^{12} to C^{13} in the atmosphere must be measured over a wide range of geographic locations to learn the net flux of CO_2 between the atmosphere and the biosphere, says the panel, because the changes in C^{12}–C^{13} ratio are likely to be small compared to random errors. Other measurements the panel deems necessary include

- Better estimates of changes in land use;
- Estimated annual changes in global forest biomass;
- Determination of changes in carbon content of soil humus;
- Intercomparable mean monthly values of the partial pressure for CO_2 in the atmosphere, the ocean surface and subsurface waters;
- Refined estimates of the quantities of CO_2 released by the burning of fossil fuels;
- The dispersal of tritium from atmospheric nuclear-weapons tests in subsurface ocean waters (as a measure of advection, convection and turbulent-mixing processes in the ocean), and
- Reduction of error in the Suess effect, the decrease of atmospheric radiocarbon content over the century and a half before 1950 due to injection of C^{14}-free CO_2 into the atmosphere from combustion of fossil fuels.

Recommendations. The Revelle panel suggests that its study of possible climatic consequences of fossil-fuel use should be only part of a family of similar assessments of the most attractive alternative energy sources' environmental impacts. The panel recommends a "comprehensive worldwide research program" of a uniquely interdisciplinary nature to carry on the investigation of CO_2-related climatic effects. "Consideration should be given," says their report, "to the establishment at the national level of a mechanism to weave together the interests and capabilities [of scientists and Government agencies] in dealing with climate-related problems." This "Climatic Council," as the panel describes it, would coordinate studies of the CO_2 cycle, energy demand, future population changes and ways of mitigating the effects of global climatic shifts.

Revelle and his colleagues conclude that there are two sorts of countermeasures possible—the reduction of actual climatic changes, or adaptation to such changes with a view to minimizing their impact on human life. Adaptation, they say, is the most readily approached; attempts to reduce the climatic effect of additional CO_2 in the atmosphere they find to be "formidably difficult," requiring extended efforts over centuries. With an eye to the future, however, the panel also proposes an intriguing challenge: In light of the expanding knowledge and interest in climatic changes, they say, "perhaps the question that should be addressed soon is 'What *should* the atmospheric carbon-dioxide content be over the next century or two to achieve an optimum global climate?' " —FCB