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This Week's Citation Classic

Okubo S. Note on unitary symmetry in strong interactions. Prog. *Theor. Phys.* **27**:949-66, 1962.
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The SU(3) symmetry is used to classify multiplets of elementary particles. Assuming that the SU(3>breaking mass operator behaves as an eighth component of an octet operator under the SU(3) transformation, a general mass formula which expresses masses of elementary particles in terms of hyper-charge and isotopic spin has been derived. [The ***SCI***® indicates that this paper has been cited over 495 times since 1962.]

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"For one year from September 1960 to August 1961, I was a visiting research associate at CERN, Geneva, Switzerland, arranged by R.E. Marshak who was also spending the same period at CERN. At that time, the only well-established symmetry in elementary particle physics was the isotopic spin group SU(2) = SO(3), together with the Gell-Mann-Nishijima relation. Many physicists had unsuccessfully tried to enlarge the symmetry to the SO(4) group. I was interested in formulating a SUP) symmetry based upon the Sakata model where only proton, neutron, and the A-particles are supposed to be the elementary blocks of all strongly interacting particles now called hadrons. Especially, I tried to find a mass formula for the SU(3) symmetry in analogue to the so-called vector algebra of quantum mechanics. In view of the more complicated structure of the SU(3) Lie algebra, the problem turned out to be difficult, requiring a new technique. After fruitlessly trying many different approaches, I was, however, able to solve the essential part of the problem to my satisfaction in two months of some hard work.

"Although I was offered a semi-permanent job at Rochester by Marshak after CERN, I had to remain at Tokyo, Japan until April 1962 because of difficulty in obtaining a visa to the United States. This fact accounts for listing both Tokyo and Rochester addresses on this paper. At any rate, I had time at the University of Tokyo to refine my work so that the mass formula is now also applicable to the unitary symmetry of Gell-Mann and Ne'eman, in addition to the case of the Sakata SU(3). It may be of some interest to note that in 1961, when he was at CERN, Y. Yama-guchi had proposed the same idea of the unitary symmetry independently. However, since he never published his work, the symmetry is now known as the Gell-Mann-Ne'eman's octet model. Also, a special case of the mass formula was discovered by Gell-Mann in his original paper, so that the formula is now known as the Gell-Mann-Okubo mass formula.

"The many citations of this paper were a happy surprise to me, one which I never expected. In early 1960-61, any study of hygher symmetry was more or less regarded by the majority of physicists to be at best an academic exercise without any physical relevance. The turning point in acceptance of the unitary symmetry together with the mass formula was undoubtedly the experimental discovery of the Ù hyperon by workers at Brookhaven National Laboratory in 1964. This confirmed the validity of the mass formula. Another reason for the many citations to this paper is perhaps due to the fact that this paper is probably the first simple exposition of the mathematical tool required for the SU(n) symmetry in elementary particle physics, which elementary particle physicists were unfamiliar with at that time. Since then, the quark model of Gell-Mann and Zweig (in contrast to the Sakata model) has been firmly established, and knowledge of the SU(n) symmetry is now a prerequisite for any graduate student interested in elementary particle physics."