lopment' but we see no perceptible change in any of our out-dated systems. Our multitude problems continue to bog us down in spite of all the podium speeches. As is often heard in 'top' circles, its no more a question of adequate resources, but that changes require focus, steadfast will and a clear mind. If funds are in plenty, then the glitch could be in funds not being directed quickly enough or the lackadaisical approach to their implementation. We better hurry before the rest of the world passes us by. The P. Rama Rao Report in its concluding remarks had hoped that 'its recommendations would come into force in August 1999 and India would be placed in a strong position to look forward to a technologically brightened future'. It is now crunch-time for the Indian Engineering fraternity to speak out aloud on the progress, or the lack of it.

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**RESEARCH NEWS**

# A possible explanation for MACHOs: A candidate for dark matter – from quark–hadron phase transition

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A possible constituent for Massive Astrophysical Compact Halo object or MACHO – a candidate for dark matter, has recently been proposed by Banerjee *et al.*[1]. Way back in 1933, Fritz Zwicky found that the mass that he could account for in stars and galaxies is only a small fraction of the mass needed to account for in stars and motion observed in Coma cluster. Over the years, from different observations, astronomers have found a similar discrepancy for other galaxy clusters, as well as for individual galaxies. These discrepancies led to the foundation of 'dark matter'; matter which cannot be observed directly and the evidence for dark matter is only gravitational.

Present consensus is that the visible matter constitutes only around 5–10% of the total matter of the universe, and the rest is in the form of dark matter. There may also be a large amount of energy in the form of dark energy to account for the accelerated expansion of the universe. The form of dark energy remains a total mystery even today, though it now seems from Banerjee *et al.*[1] that the cold dark matter can be explained in a natural way. While there may well be more than one type of dark matter, such as baryonic or non-baryonic, hot (relativistic) or cold (non-relativistic), large-scale structure calculations suggest that non-relativistic (cold) dark matter (CDM) constitutes a dominant fraction of dark matter.

Recently there has been experimental evidence of at least one form of dark matter, namely MACHOs in the halo of the Milky Way Galaxy. The light from a distant star, passing by a MACHO, bends due to the large gravitational field of the MACHO. The bending of light is a consequence of Einstein's General Theory of Relativity and is known as gravitational lensing. In the present case, since the lens is relatively small (compared to the galaxy), multiple images are not observed. On the other hand, due to relative motion between the stars and MACHOs, the lensing effect causes an increase in the brightness of that distant object. Using this phenomenon, known as gravitational microlensing, around 13–17 MACHOs have been detected in the Milky Way halo.

A definite candidate for MACHOs has been proposed by Banerjee *et al.*[1]. It is suggested that MACHOs have evolved out of the strange quark nuggets (SQNs) formed during the first-order phase transition of the early universe from quark phase to hadronic phase, at a temperature around 100 MeV ($10^{-5}$ s after the Big Bang). During this phase transition, hadronic matter starts to appear as individual bubbles in quark–gluon phase[2,3]. With the progress in time, more bubbles appear and they expand to form a network of such bubbles (percolation) in which the quark matter gets trapped. With further cooling of the universe, these trapped domains of quark matter shrink rapidly without significant change of baryon number, and eventually evolve to SQNs through weak interactions with almost nuclear density[4]. These objects are stable and calculation shows that to explain all the CDM, the baryon number of an SQN should be $\sim 10^{42-44}$ (ref. 5), assuming all SQNs to be of same size. These SQNs with masses $\sim 10^{44}$ GeV and size $\sim 1$ m would have very small kinetic energy compared to their mutual gravitational potential.

Hence, gravitational collapse seems to be a natural fate. The only agent that can prevent a collapse is radiation pressure (protons and neutrinos). It has been shown that indeed the effect of radiation pressure remains quite substantial until it weakens below certain critical value due to the drop in the temperature of the ambient universe. At the time when gravitational force overcomes radiation pressure, it is found that for a MACHO of size 0.24 $M_\odot$ ($M_\odot$ is the solar mass) one would need $2.44 \times 10^{14}$ SQNs each with baryon number $10^{42}$. The total number of MACHOs in the Milky Way halo is $\sim 10^{13-14}$ and the corresponding optical depth of these objects is shown to be com-

parable with the observed value. Hence the gravitational clumping of SQNs gives a natural explanation for the observed halo MACHOs.

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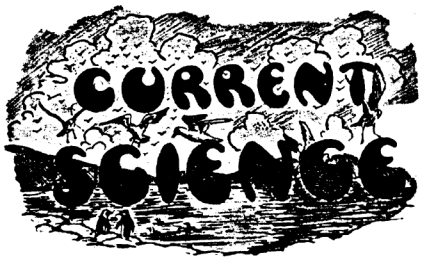
## FROM THE ARCHIVES

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### University for Orissa

In determining the type of university most suitable for Orissa, the University Committee appointed by the Congress Ministry in 1938 has reached the decision that a wholly centralised varsity would not accord with the actual requirements of the Province, and would not be justified either by the distribution of the collegiate institutions in the State or by the stage of educational development now attained. Presumably after carefully investigating the wealth of experience accumulated in many places and in many directions, the Committee have favoured the establishment of an affiliating university at Cuttack, and it must be remembered that there is already a similar university functioning at Patna. Since the older Universities of Calcutta, Madras and Bombay still retain the garb though not the clothes of a mere examining body, it may be reasonable to suppose that the judgment of the Orissa Committee is wise, especially in view of the circumstances prevailing in the Province. The jurisdiction over which the new university will exercise its control is fairly limited,—an advantage which will promote its efficiency. Further it may not be absolutely a correct policy to break with the past.

It is true that under the stimulus of the Universities Act of 1904 and under the influence of public opinion people have come to regard that a university should share in the actual work of teaching, instead of remaining an impassive body controlling higher education through public examinations. Not until the impact of popular demand became irresistible, did the universities established in 1857 readjust their constitutional machinery. The various reports of University Commissions have emphasized and approved the popular feeling that the universities must be invested with the responsibility of co-ordinating their functions with the social, physical and intellectual needs of their students, and with the economic and industrial activities of the State. The recent university projects inaugurated in the last few years accentuate and reflect this higher conception of the functions of a university.

. . . What India wants is a network of inspiring seminaries of knowledge, within whose halls there are men who are little universities in themselves, and whose creative genius will fertilise the minds of young men, who in their turn will blossom into dynamic intellectual apostles. Sir Venkataraman placed in Sahara, Bow Bazaar or in the Indian Institute of Science is a smiling university in himself. It is obvious that, since mankind has not yet invented a process of making bricks without straw, the Indian universities suffering from chronic financial anaemia cannot be accused of lagging behind their foreign congeners, which can very well stand a considerable amount of transfusion. Nevertheless it must be gratefully acknowledged that the Indian universities struggling under severe handicap have produced work which is at once impressive and significant. Orissa need not be troubled over the type. If it has ample financial support and potential men such as Sir Venkataraman, Professor Saha, Dr. Ghosh, Professor Sahni, Professor Krishnan and Sir Radhakrishnan, the proposed affiliating university will achieve distinction.

Even more serious than financial inadequacy is the unmanageable size of student population,—a condition hostile to the successful evolution of a corporate intellectual communion in the universities, comparable to the best traditions of the older British universities. All attempts in the direction of imposing restraints on the free admission of students must be deprecated. The greatest reproach of our universities is that they act as a sort of one-way traffic system, leading the students ultimately into blind alleys, instead of being centres of divergent radiation, along which young men could march in a spirit of hope and courage to places where they might fulfil their destiny. All the existing universities have a handsome but unexpressive face; viewed from any standpoint, their duplication is indefensible. . . .

The reconstruction of our universities for direct use to the society is a duty as instant as that of improving natural knowledge for discovery. They are not to be regarded merely as a channel of escape to a world of discontented young men, and should not seek vindication on remote and abstract criteria. A university is at bottom a social function, with inescapable social responsibilities and obligations, and if our universities are to live as a vital force, they must ever keep human values and problems in the forefront, and they must justify their existence by their contributions to the enrichment of the spiritual and material wealth of the nation.