## **Pangaea and Gravitational Waves**, Prof. J S Rao, President, The Vibration Institute of India, Bangalore

Newton's 17th century idea of gravity is a force of attraction between two particles in the universe; Einstein 98 years ago defined Gravity as a distortion in the fabric of Space and time and not a Force of Attraction. Einstein said that matter tells space how to curve; space tells how matter should move. Essentially the two theories differ when the speed of orbiting bodies get closer to speed of light. Einstein provided for communication between objects, e.g., Sun to Earth and then to Moon to keep them in their orbits. Einstein introduced Gravitational waves that communicate information between two colliding objects. They carry a part of energy of collision from the loss of mass and transfer it to the objects on way of travel that may be around a billion of light years. The earth is subjected to a continuous exposure of these gravitational waves and receives small amounts of energy. Einstein's theory was almost accepted almost immediately, but gravitational waves were detected for the first time by Laser Interferometry Gravitational Wave Observatory (LIGO) only on September 14 2015 and announced on 11th February 2016. The measured strain was minutely small of the order of $10^{-22}$. The measurement made was most precise yet, a 100th of the diameter of a Proton in the nucleus of an atom. A brief explanation of the theory followed by a LIGO to measure this small strain will be first described.

Wegener announced his continental drift theory in 1915 by his observation of the present continental outlines and the fossils in separated continents hundreds million years ago. However no origin of force to break and move the supercontinent mass over the earth's mantle from the south pole could be accounted. Through Hubble's law of expanding Universe it can be deduced that the gravitational waves emanate from observable collisions in the southern celestial hemisphere; thus providing the force required breaking and moving the continents to the current locations. It also provides the force required for the moving tectonic plate of Gondwana land to abet and push against the Eurasia continent plate in forming the Himalayan mountains. A simulation of these continental drifts under the influence of the strain is required to see if the 300 million years' time matches.

Since energy in the form of strain energy is passed on to the earth, the earth itself can be modeled as a finite element model to study the thermal rise and also the earthquakes that occur in the abetting tectonic plates. The earth is too big for the engineering structural codes to be used. A scaled down model is necessary to accommodate the size of the earth. Since the model is scaled down an appropriate scaling factor is required for the strain to keep the strain energy same in the original as well as scaled down models. These aspects are briefly explained and the resulting global rise in temperature is indicated under the small strain recoded and made public.

On April 16th this year we have seen three earthquakes in Ecuador, Afghanistan-Pakistan border and Kumamoto all of them lying on the March equinox ecliptic. The gravitational wave that emanate from southern celestial hemisphere normal to the ecliptic at this time might have provided the required force to move the plates causing an earth quake. Considerable modeling and numerical work is required in this direction. A fracture mechanics model of the earth quake region is given.

The gravitational waves have provided a new cue to understand the multi-physics involved between Geology, Physics, and Engineering Simulation and opens up investigations for future scientists and engineers. Another important area of work is in design and fabrication of the third LIGO in the world to measure and provide the data in another 4-5 years of time. Fortunately the present government has provided for the budget.

*Gist of the lecture delivered at the monthly scientific meeting of the Geological Society of India, Bangalore.*