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An arithmetic approach for modeling of seismic activity

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The "arithmetic seismic activity model" is proposed by Fujiwara (2014) and the seismic activity is modeled by using the prime numbers to express the seismic activity that follows the G-R law as mathematical model. Although the "arithmetic seismic activity model" is one that has been inferred from the phenomenological similarities between seismic activities and the prime number distributions, there may be some mathematical and physical meanings behind the model. Focusing on the relationship called trace formula, a study have been conducted.

We consider a correspondence between earthquakes and prime numbers. We parameterize occurrence time of earthquakes as the prime numbers and magnitude of earthquakes as the interval of prime numbers. Then we obtain a relationship similar to G-R law. We call the model obtained by this correspondence as "arithmetic seismic activity model". In the "arithmetic seismic activity model", earthquake is equivalent to prime number. Earthquake prediction is equivalent to prediction of emergence of prime numbers.

Trace formula is an equation obtained by calculating the trace of certain operator in two ways. A common feature in the trace formula, the sum on the prime elements in the geometric side is equal to the sum on the eigenvalues in the spectrum side. By generalizing these characteristics of the trace formula, it is possible to regard the explicit formula on prime numbers obtained by Riemann as one of the trace formula. Point processes in which points are irregularly occurred are difficult to handle in mathematical modeling. By using the trace formula, however, it is possible to express a point process as a sum of relatively simple continuous functions. Thus, by using the trace formula, an irregular point process is expected to be modeled as an eigenvalue problem of certain dynamical system.

An earthquake is understood as a phenomenon that corresponds to a change in the energy level of the field. Using certain quantum system, we consider to model a field of earthquake occurrence. Considering a Hamiltonian of the field of earthquake occurrence, we set earthquake occurrence as an eigenvalue problem for the Hamiltonian. If we can show that the eigenvalue problem is associated with the zeta function, we can expect to explain the similarity between the distribution of the prime and seismic activity. At present, any dynamical systems can explain seismic field based on this concept are not known. On the other hand, researches on the distribution of prime numbers are progressing to try to understand the distribution of zeros of the Riemann zeta function, which is equivalent to the distribution of prime number, as an eigenvalue problem of a quantum dynamical system.

Connes derived a trace formula of Selberg type by considering the operation of an idele class group on a square integrable function space that is defined on a space of adele class and showed that to prove the trace formula and to prove the Riemann conjecture are equivalent. Volovich proposed the p-adic quantum mechanics and considered an extension of quantum mechanics onto an adele space. As a part of their research, harmonic oscillators on an adele space are introduced and the Mellin transforms of them are shown to be expressed using the Riemann zeta function. Thus, eigenvalue problems of dynamical systems that are configured on an adele space are found to be associated naturally with the Riemann zeta function.

In this study, referring to the idea of extension of the quantum mechanics onto an adele space, we try to formulate the quantization (non-commutativization) of the continuum mechanics that gives the physical basis of seismology. On the basis of these basic studies, an attempt is made to regard earthquake oocuurence as eigenvalue problems of dynamical systems on an adele space.

Keywords: number theory, prime number, earthquake, trace formula, adele