6

OTHER RESEARCH ACTIVITIES

An Indigenous software for generating “Penta-Graphene Sheet” and “Penta-Graphene Nanotube” has been developed for the first time. The “lattice parameter” used for analyzing carbon nanostructures in nonlocal continuum mechanics has been precisely identified. Noise is ubiquitous to both the observational and experimental data. Improper handling of noise could potentially skew the conclusions drawn from the data analyses. These aspects had been examined in the context of two modern data analysis algorithms.

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6.1 Indigenous software for penta-graphene nanotube structure generator

Using in-house code, the Penta-Graphene Nanotube Structure Generator Software has been developed for the first time. The Penta-Graphene structure consists of five carbon atoms in different planes. In open source platform, there exists no such software to generate the penta-graphene structure. The Penta-Graphene Sheet and Penta-Graphene Nanotube are shown in Figure 6.1 and Figure 6.2, respectively.

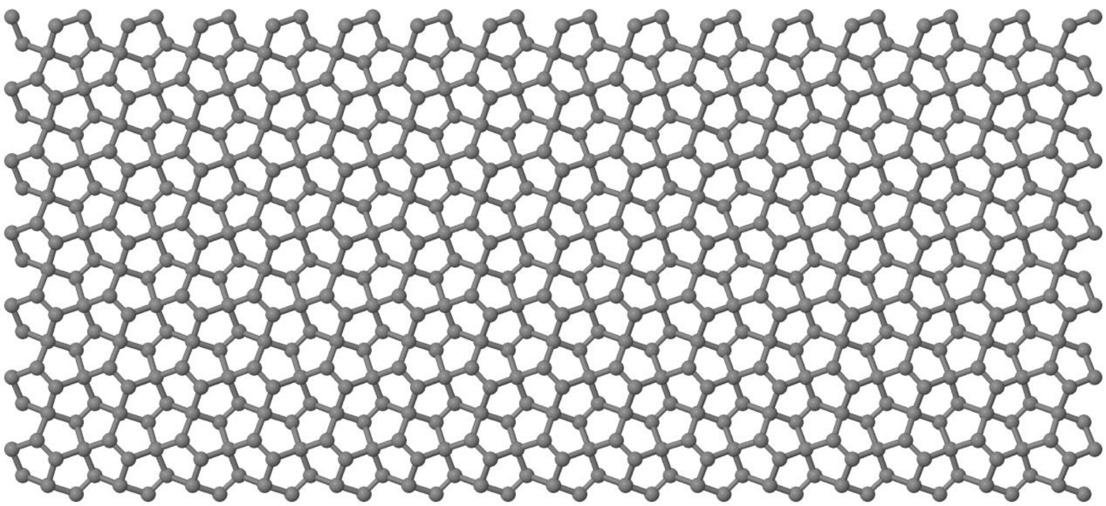

Figure 6.1 Penta-Graphene Sheet with Chirality as (15,0)

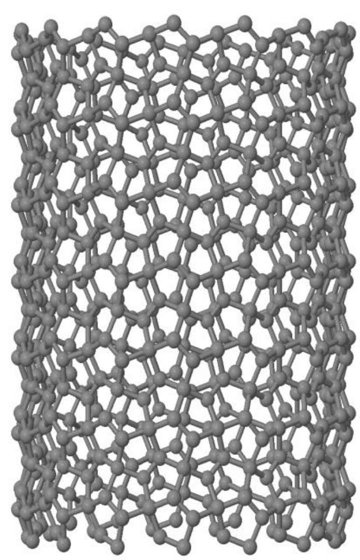

Figure 6.2 Penta-Graphene Nanotube with Chirality as (15,0)

6.2 Nonlocal bi-Helmholtz stress gradient theory and carbon nanostructures

The group velocity of nonlocal continuum model failed to capture the atomic-model behavior. For the first time, the complex conjugate numbers have been proposed in the continuum stress-gradient model using nonlocal elasticity. The nonlocal bi-Helmholtz stress gradient theory has been proposed with two nonlocal parameters. The “lattice parameter” value used in “nonlocal continuum models” is 0.142 nm for analyzing nanostructures like Carbon Nanowire, Carbon Nanorod, and Graphene. The atomic distance between two-carbon atoms is 0.142 nm. Many researchers misconceived that the “lattice parameter” value as a carbon-carbon bond length. It has been observed that the correct value for “lattice parameter” is 0.246 nm.

6.3 Impacts of noise on the modes extracted by two data analysis algorithms

We report, here, the prominent oscillations in the Indian Ocean SST extracted by Dynamic Mode Decomposition (DMD) and Non-linear Laplacian Spectral Analysis (NLSA). In addition, the sensitivities of their modes to random noise are presented. The latter aspect is important to understand, as the characteristics of noise can vary from one batch of data set to another, even when these batches originate from an identical model simulation or an experiment. The results obtained are based on the monthly observations of Indian Ocean SST from the Extended Reconstructed Sea Surface Temperature dataset. The two versions of datasets, which differ only in terms of the realization of random noise have been analyzed to examine the impacts of noise.

In general, the characteristics of DMD modes extracted from the two versions of SST are almost identical. Thus, it is clear that the structures and periods of weakly damped DMD-modes are not impacted by random noises. Nevertheless, it does change the decay/growth rates of these seasonal oscillations. Apart from the well-known annual and semi-annual cycles, the DMD analysis also could extract a few additional modes having the interannual periods. A comparison of the characteristics of inter-annual DMD-modes extracted from the two datasets reveals that their spatial-structures, periods and decay rates are very different. This suggests that, unlike the seasonal DMD-modes, the fundamental properties of the inter-annual DMD-modes are dictated by the instantaneous noise. In short, the findings emerged from these exercises imply that a prediction based on a fixed set of inter-annual modes can potentially be erroneous since the characters of inter-annual DMD-modes of Indian Ocean change with the noise. However, the noise depends in turn on the input data and the number of leading SVD-modes used to reduce the dimensionality. Therefore, the quest for reduced order models for the inter-annual predictions needs to be more attentive to the neglected components.

A comparison of the eigen spectra, time series, and spatial structures of the leading NLSA-modes extracted from the two versions of datasets had brought out the following facts. Like in DMD, the first NLSA-mode has the spatial structures of long-term monthly mean of Indian Ocean SST. The annual and semi-annual cycles are captured by the mode-pairs (2, 3) and (4, 5) respectively. However, in both cases, NLSA algorithm failed to detect in the inter-annual modes. There exist considerable disagreements, in terms of magnitudes and phases, between the sums of 25 leading NLSA-modes (i.e., the reconstruction) extracted from the two datasets. Hence, these two reconstructions are not the accurate representations of the signals embedded in the inputs. Apart from the noise-sensitivities reported here, the sensitivity of NLSA-modes to the in-built parameters like ‘number of neighbors’ (used in the estimation of transition probability matrix) is also a matter of concern.