Old formulas lead physicist to new understanding of the brain

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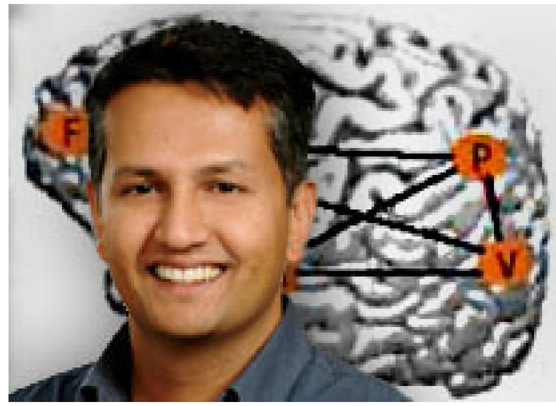

Sometimes, a new problem calls for an old solution. For Mukesh Dhamala, assistant professor of physics, that meant going back to an early-19th-century theory to refine his analysis of information flow inside the brain. Dhamala's latest research appears in a paper he co-authored that will be published in the January 11 edition of Physical Review Letters. Basically, the paper addresses the problem of mapping information flow patterns in dynamic systems - for example, the patterns of neural interactions in the brain that underlie thought and behavior. Dhamala and his co-authors argue that the best way to approach the issue is through two relatively old systems of theoretical physics. Their work uses Fourier transforms, equations first laid out in the early 19th century, and continuous wavelet transforms, introduced in the seventies. These methods are widely used in science and engineering, but have not yet been brought to bear on these particular biological problems. The old equations, Dhamala says, offer a better way to approach the question of cause and effect inside the brain – that is, to figure out which way impulses flow through chains of neurons. Physics equations aren't an obvious choice for understanding biological problems. But new advances in medical imaging have produced new kinds of data for scientists to work with. Scientists are still looking for the most accurate – and the most revealing – ways to analyze that data. Up to now, researchers have been using what are known as parametric modeling techniques. In these methods, researchers first build a mathematical model for the data at hand and then use the model to analyze the data. There are two problems with the parametric approach, Dhamala said. First, the results are unavoidably shaped by the model itself – build a different model, and a different analysis will come out. Second, the models often fail to fully account for the complexities of the data, Dhamala said. Measurements are now so fine that scientists can see the spikes of electrical activity as an individual ion passes from neuron to neuron. But parametric models are not suitable for analyzing these "spike trains." The nonparametric approach that Dhamala and his colleagues have proposed can handle that level of detail, however. Their methods allow researchers to calculate their results directly from the data, without building a mathematical model first. "It's just a more principled way to see the data," Dhamala said. Dhamala, who is also associated with the Brains and Behavior program and the Center for Behavioral Neuroscience at Georgia State, has a Ph.D. in theoretical physics. His research, however, straddles the line between physics and biology, using the theories of the former to dig through the data of the latter. It's an unusual niche, but an important one. "The brain is so complex," Dhamala said. "However, modern biomedical imaging/recording technology offers us a unique opportunity to increase our understandings of the brain, both in health and disease. But, the analysis requires a multidisciplinary approach.”