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MIT Research in the News

Germs that go to great lengths
April 16th, 2014

A new study by MIT researchers shows that the droplets our noses and mouths release during coughs and sneezes can travel much further than previously thought. John Bush, a professor of applied mathematics, and Lydia Bourouiba, an assistant professor in the department of Civil and Environmental Engineering, are two of the coauthors on a recent paper, "Violent expiratory events: on coughing and sneezing." The researchers directly observed sneezing and coughing, and also simulated it in the lab, and found that coughs and sneezes produce "turbulent buoyant momentum puffs," or respiratory clouds, that



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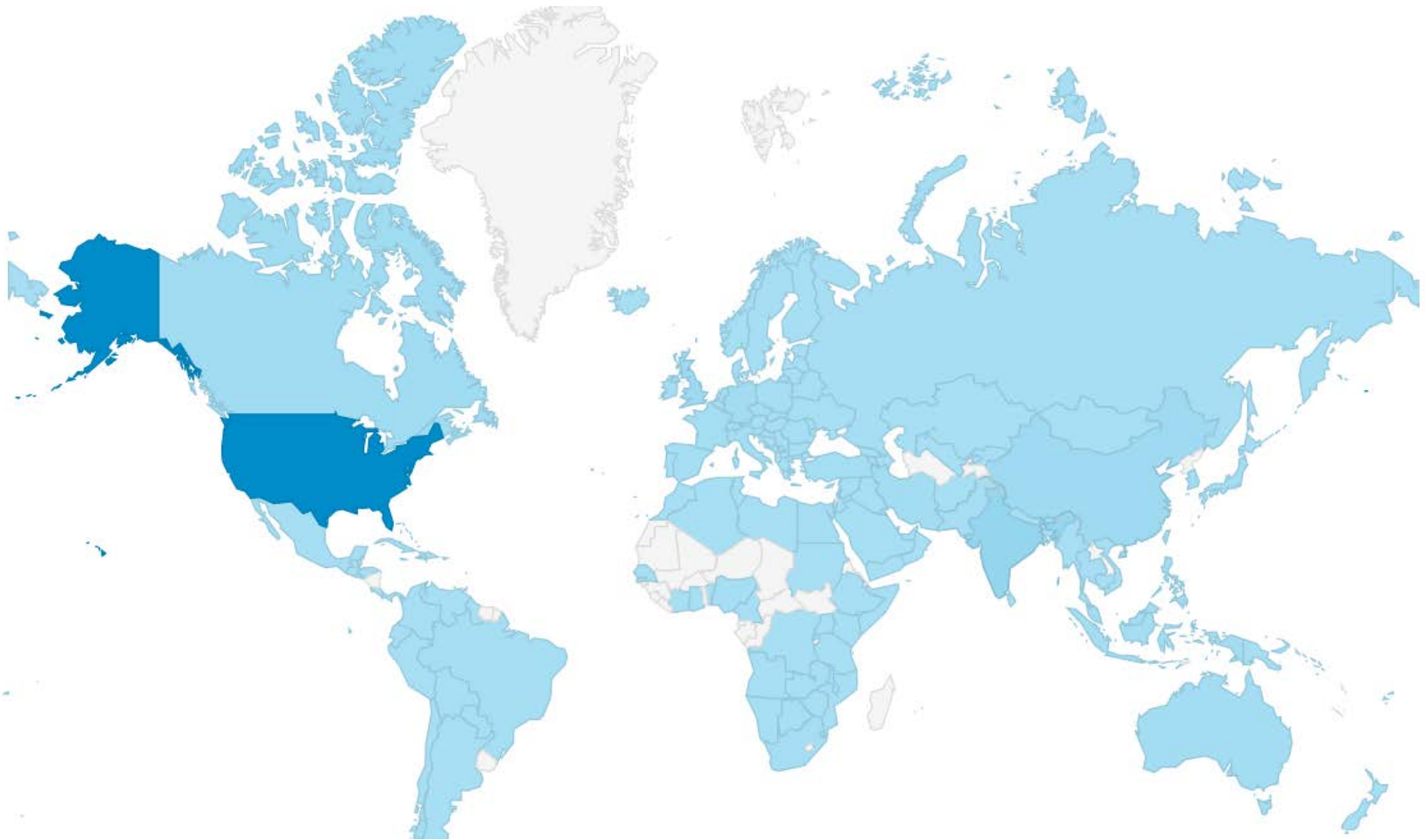
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













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Published Version

Functional evolution of free quantum fields

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Received 16 February 1999

Abstract. We consider the problem of evolving the state of a quantum field between any two (in general, curved) Cauchy surfaces. Classically, this dynamical evolution is represented by a canonical transformation on the phase space for the field theory. We show that this canonical transformation cannot, in general, be unitarily implemented on the Fock space for free quantum fields on flat spacetimes of dimension greater than 2. We do this by considering time evolution of a free Klein-Gordon field on a flat spacetime (with toroidal Cauchy surfaces) starting from a flat initial surface and ending on a generic final surface. The associated Bogolubov transformation is computed; it does not correspond to a unitary transformation on the Fock space. This means that functional evolution of the quantum state as originally envisioned by Tomonaga, Schwinger and Dirac is not a viable concept. Nevertheless, we demonstrate that functional evolution of the quantum state can be satisfactorily described using the formalism of algebraic quantum field theory. We discuss possible implications of our results for canonical quantum gravity.

PACS numbers: 0370, 0420C, 0460D

1. Introduction

In this paper we consider some aspects of dynamical evolution in quantum field theory. Specifically, we examine the description of dynamics in which one evolves the state of a quantum field from any initial Cauchy surface to any final Cauchy surface, rather than just between Cauchy surfaces of constant Minkowskian time. This way of formulating dynamical evolution dates back to the inception of relativistic quantum field theory. We begin our introduction to the main ideas via a brief historical sketch.

The idea of evolving a quantum field from any Cauchy surface to any other seems to have originated in the mid 1940s with the work of Tomonaga [1] and Schwinger [2] on relativistic quantum field theory. Tomonaga and Schwinger wanted an invariant generalization of the Schrödinger equation, which describes time evolution of the state of a quantum field relative to a fixed inertial reference frame. By allowing for all possible Cauchy surfaces in the description of dynamical evolution one easily accommodates all possible notions of time for all possible inertial observers. Thus a dynamical formalism incorporating arbitrary Cauchy surfaces does allow for an invariant generalization of the Schrödinger equation. Since the space of Cauchy surfaces is infinite dimensional, it is impossible to describe time evolution along arbitrary surfaces by using a single time parameter. In essence, one needs a distinct time parameter for every possible foliation of spacetime. As shown by Tomonaga and Schwinger, if one formulates dynamics in terms of general Cauchy surfaces, the resulting dynamical evolution

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Journal information and pagination

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Abstract

We consider the problem of evolving a quantum field between any two (in general, curved) Cauchy surfaces. Classically, this dynamical evolution is represented by a canonical transformation on the phase space for the field theory. We show that this canonical transformation cannot, in general, be unitarily implemented on the Fock space for free quantum fields on flat spacetimes of dimension greater than 2. We do this by considering time evolution of a free Klein-Gordon field on a flat spacetime (with toroidal Cauchy surfaces) starting from a flat initial surface and ending on a generic final surface. The associated Bogolubov transformation is computed; it does not correspond to a unitary transformation on the Fock space. This means that functional evolution of the quantum state as originally envisioned by Tomonaga, Schwinger, and Dirac is not a viable concept. Nevertheless, we demonstrate that functional evolution of the quantum state *can* be satisfactorily described using the formalism of algebraic quantum field theory. We discuss possible implications of our results for canonical quantum gravity.

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TECHCAST

**Bridging the Gap between Digital Measures and Digital Commons in
Support of Open Access:
Or, How I learned to stop worrying and love human mediation**

ANDREW WESOLEK

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Introduction

Utah State University is home to a thriving institutional repository (called DigitalCommons@USU), an instance of the activity-reporting tool, Digital Measures (DM), and, as of May 30th, 2012, an institutional open access policy. In 2008, shortly after USU Libraries launched the institutional repository, efforts were made to harness the university-wide reporting capabilities of Digital Measures. The latter, managed by USU's Office of Analysis, Assessment, and Accreditation, was seen to be an important tool in developing the IR, as faculty are required to record their activities and intellectual contributions to this internal database. These initial efforts, however, were not largely successful and subsequently deprioritized.

A changing campus culture, the passage and implementation of an open access policy, and changes in the capabilities of Digital Measures, though, prompted

¹ This article describes work performed while the author served as Scholarly Communication Librarian at Utah State University. He held this position until August of 2013.

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