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What it is and what it means for us

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Fall, 2012
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# History of the Policy

- Harvard first in 2008
  - Followed by institutions like MIT, Duke, KU, and Princeton
- Our Policy: brought to the Faculty Senate in January of 2012
  - Various iterations until unanimously supported as Policy 535
  - President Albrecht signed it into effect on May 30th
  - USU Libraries charged with administering the policy

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# USU Policy 535

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Scholarly Articles:

Articles that describe the fruits of a scholar's research that he/she gives to the world for the sake of inquiry and knowledge without the expectation of payment

# And that means…

This policy is a tool to help us negotiate our publishing contracts

This policy improves access to our work, and thus increases its impact

This policy reflects our commitment to the values of a land grant institution

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- This policy is not punitive—it is a tool to help us retain our rights and to help us negotiate for wider dissemination of our works

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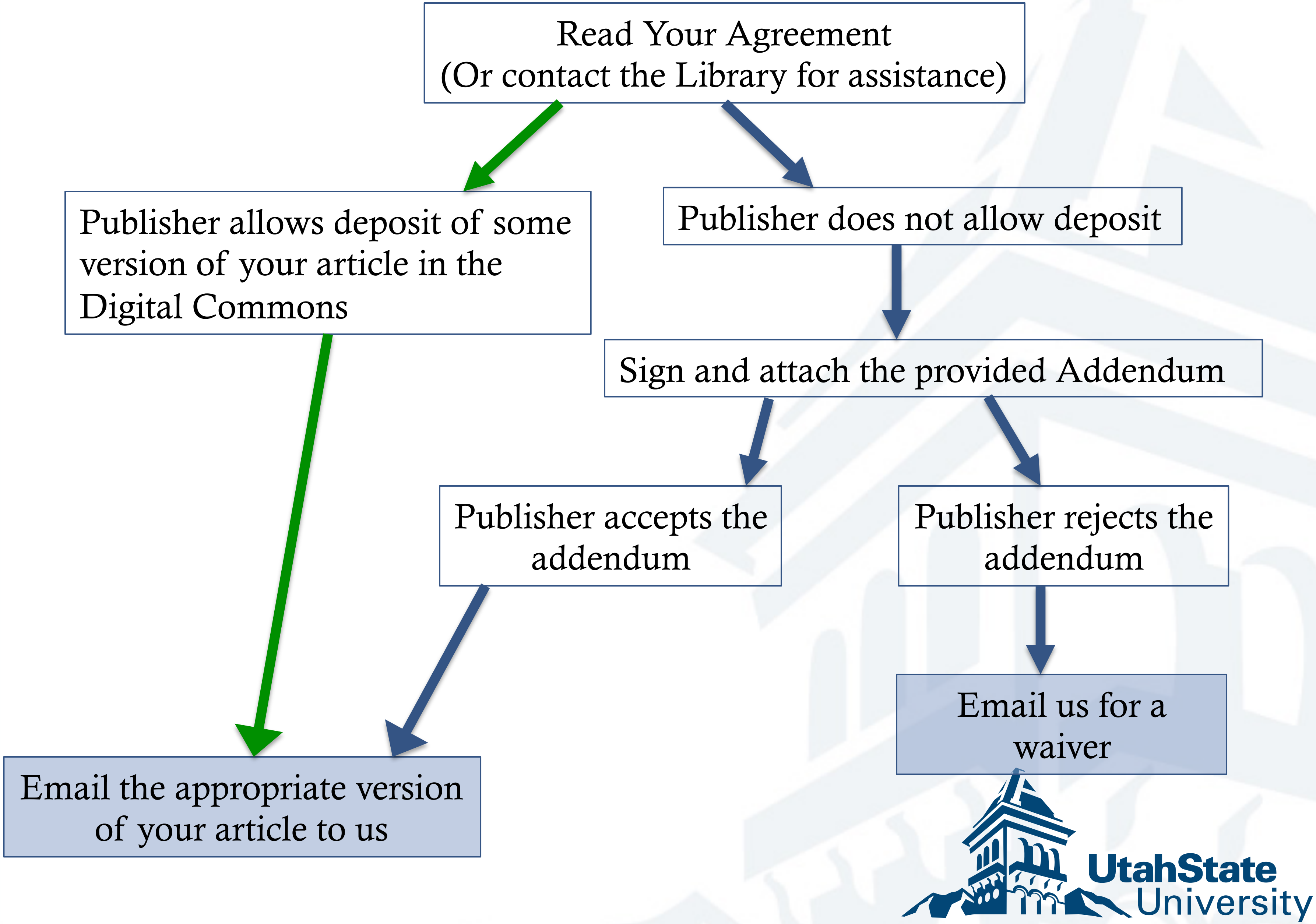
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## Functional evolution of free quantum fields

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**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.

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### 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

 

# Author's Version

# Functional evolution of free quantum fields

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*November 23, 1998*

## 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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**Comments**

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