

LOW-ENERGY NUCLEAR REACTIONS USING TIME-DEPENDENT DENSITY  
FUNCTIONAL THEORY

By

Kyle Godbey

Dissertation

Submitted to the Faculty of the  
Graduate School of Vanderbilt University  
in partial fulfillment of the requirements  
for the degree of

DOCTOR OF PHILOSOPHY

in

Physics

May 8<sup>th</sup>, 2020

Nashville, Tennessee

Approved:

Date:

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Senta V. Greene, Ph.D.

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J. K. Holley-Bockelmann, Ph.D.

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Norman H. Tolk, Ph.D.

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Sait A. Umar, Ph.D.

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Kalman Varga, Ph.D.

LOW-ENERGY NUCLEAR REACTIONS USING TIME-DEPENDENT DENSITY  
FUNCTIONAL THEORY

Kyle Godbey

Dissertation under the direction of Professor Sait Umar

Nuclei are small many-body quantum systems which account for most of the currently observable mass of the universe. This abundance suggests that the study of interactions between atomic nuclei can enhance understanding of physics at all scales, despite the relatively short distance of the nuclear force. As systems of nuclei can have several hundreds of individual particles, the mean-field approximation is often invoked to make calculations of nuclear reactions numerically tractable. A number of investigations have been performed relating to nuclear fusion and quasifission, as well as the development of new tools and techniques to aid in the study of nuclear and quantum many-body physics. A significant focus has been placed on the investigation of transfer and how affects nuclear reactions. Specifically, transfer is found to substantially enhance sub-barrier nuclear fusion, and deformed shell effects are found to drive the total transfer seen in quasifission reactions. Furthermore, transfer between symmetric systems is investigated and offers a promising path towards the creation of neutron-rich nuclei via multinucleon transfer processes.

Approved \_\_\_\_\_ Date \_\_\_\_\_  
Sait Umar, Ph.D.



Kyle Godbey &lt;kylegodbey@gmail.com&gt;

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## Title Page + Abstract Approval

4 messages

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**Kyle Godbey** <kyle.s.godbey@vanderbilt.edu>

Tue, Mar 17, 2020 at 11:13 AM


To: "Umar, S A" <sait.a.umar@vanderbilt.edu>, "Greene, Senta V" <senta.v.greene@vanderbilt.edu>, "Holley-Bockelmann, Jocelyn K" <k.holley@vanderbilt.edu>, "Tolk, Norman H" <norman.tolk@vanderbilt.edu>, "Varga, Kalman" <kalman.varga@vanderbilt.edu>, etdadmin@vanderbilt.edu

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**Sait Umar** <sait.a.umar@gmail.com>

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Cc: "Greene, Senta V" <senta.v.greene@vanderbilt.edu>, "Holley-Bockelmann, Jocelyn K" <k.holley@vanderbilt.edu>, "Tolk, Norman H" <norman.tolk@vanderbilt.edu>, "Varga, Kalman" <kalman.varga@vanderbilt.edu>, etdadmin@vanderbilt.edu

I approve the abstract and the titlepage.

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**Greene, Senta V** <senta.v.greene@vanderbilt.edu>

Tue, Mar 17, 2020 at 11:16 AM

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Senta V Greene  
Stevenson Professor of Physics  
Department of Physics and Astronomy  
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**Tolk, Norman H** <norman.tolk@vanderbilt.edu>  
To: "Godbey, Kyle S" <kyle.s.godbey@vanderbilt.edu>

Tue, Mar 17, 2020 at 12:39 PM

I approve. Norman Tolk

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> On Mar 17, 2020, at 11:13 AM, Godbey, Kyle S <kyle.s.godbey@vanderbilt.edu> wrote:

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**Tolk, Norman H** <norman.tolk@vanderbilt.edu>

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Cc: "Tolk, Norman H" <norman.tolk@vanderbilt.edu>

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On Mar 17, 2020, at 11:44 AM, Marilyn Tolk <tolkmn@comcast.net> wrote:

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On Mar 17, 2020, at 11:38 AM, Tolk, Norman H <norman.tolk@vanderbilt.edu> wrote:

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Begin forwarded message:

**From:** "Godbey, Kyle S" <kyle.s.godbey@vanderbilt.edu>  
**Date:** March 17, 2020 at 11:13:43 AM CDT  
**To:** "Umar, S A" <sait.a.umar@Vanderbilt.Edu>, "Greene, Senta V" <senta.v.greene@Vanderbilt.Edu>, "Holley-Bockelmann, Jocelyn K" <k.holley@Vanderbilt.Edu>, "Tolk, Norman H" <norman.tolk@vanderbilt.edu>, "Varga, Kalman" <kalman.varga@vanderbilt.edu>, ETDAdmin <etdadmin@vanderbilt.edu>  
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**Kelly Holley-Bockelmann** <k.holley@vanderbilt.edu>

Tue, Mar 17, 2020 at 12:24 PM

To: "Tolk, Norman H" <norman.tolk@vanderbilt.edu>

3/17/2020

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I approve!

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**Varga, Kalman** <kalman.varga@vanderbilt.edu>

Tue, Mar 17, 2020 at 12:50 PM

To: "Holley-Bockelmann, Jocelyn K" <k.holley@vanderbilt.edu>, "Tolk, Norman H" <norman.tolk@vanderbilt.edu>

Cc: "Godbey, Kyle S" <kyle.s.godbey@vanderbilt.edu>, "Umar, S A" <sait.a.umar@vanderbilt.edu>, "Greene, Senta V" <senta.v.greene@vanderbilt.edu>

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**From:** Kelly Holley-Bockelmann <[k.holley@vanderbilt.edu](mailto:k.holley@vanderbilt.edu)>

**Sent:** Tuesday, March 17, 2020 12:24 PM

**To:** Tolk, Norman H <norman.tolk@Vanderbilt.Edu>

**Cc:** Godbey, Kyle S <[kyle.s.godbey@vanderbilt.edu](mailto:kyle.s.godbey@vanderbilt.edu)>; Umar, S A <sait.a.umar@Vanderbilt.Edu>; Greene, Senta V <senta.v.greene@Vanderbilt.Edu>; Varga, Kalman <kalman.varga@Vanderbilt.Edu>

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