

# Kepler AsteroSeismic Investigation (KAI)

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# Overview

- Letter of direction
- Nondisclosure agreement
- KASOC
- KASC and KASC organization

# Letter of Direction

regarding asteroseismic investigation within the Kepler project  
from the Kepler Project (Project),  
represented by William Borucki,  
to the Kepler Asteroseismic Investigation (KAI),  
represented by Ronald Gilliland.

The present letter directs the activities related to asteroseismology based on data from the Kepler mission. It defines the obligations of the KAI towards the Project, in terms of software development, reporting and delivery of asteroseismic results, as well as the timely provision of the required photometric and other data by the Project to the KAI. In addition, it describes:

- (1) Kepler Asteroseismic Science Operations Center (KASOC) set up to manage these investigations, and
- (2) the Kepler Asteroseismic Science Consortium (KASC), a group of collaborating scientists and/or institutions established to accomplish the activities of the KAI.

The letter shall remain in force through the end of Phase E of the Kepler mission

# ***Introduction***

The Kepler photometric data will represent a unique resource for asteroseismic investigations of the global properties and internal structure of a large number of stars having a broad range of different types. In particular, **asteroseismic analysis of these data will provide accurate determination of the radius of a large fraction of the stars hosting candidate planetary systems**, as determined from the transit analysis of the Kepler data, as well as estimates of the ages of the systems. Through investigation of a broad range of stars the **asteroseismic investigation will also substantially improve our understanding of general stellar evolution**, and hence strengthen the use of such modelling to further constrain the properties and evolution of the stars and systems investigated in the Kepler extra-solar planet program. The purpose of the Kepler Asteroseismic Investigation is to ensure that full use is made of this potential to benefit the Kepler investigations of extra-solar planetary systems.

# ***Asteroseismology Products to be Provided to the Project***

- Asteroseismic characterization of planet-hosting stars, including mass and particularly radius.
- Ability to distinguish cool giants from main-sequence stars through asteroseismic measures, such as estimates of the stellar radius or the shape of the background power spectrum characterizing the granulation time scale.
- Understanding of general stellar properties, including stellar structure modelling, contributing to stellar characterization.

# ***Data and Support Provided by the Project to the KAI***

The asteroseismic investigation will be based on Kepler Mission data from which information about planet transits has been eliminated, through filtering or by other means.

It is assumed that at any given time 512 targets will be observed at a one-minute cadence. It is furthermore assumed that 25 of these targets will be reserved for the guest-observer (GO) program upon its inception. At mission start all short-cadence targets will be selected for asteroseismology. As planet-hosting systems are detected an increasing number of short-cadence targets will be allocated to the study of such systems; in many cases such targets will also be appropriate for, and will be used for, asteroseismic investigations. However, an adequate number of short-cadence targets will be reserved specifically for asteroseismology throughout the mission.

# Target example

Asteroseismology

1-min Planet transit follow-up

Guest Observer

2009	2010		2011		2012		2013 →													
60 KAI																				
40 KAI				40 KAI				40 KAI				40 KAI				40 KAI				
412 KAI	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40		
					100 SWG targets															
	272			247																
	25																			
> 50 KAI targets (30-min)																				
> 50 KAI (30-min)				> 50 KAI (30-min)				> 50 KAI (30-min)				> 50 KAI (30-min)				> 50 KAI (30-m				
~170,000 Kepler targets (30-min)																				



# ***KAI Activities, before launch***

- Develop and test a ‘high-pass’ filter, or other mechanism, to remove planet information from data to be used for asteroseismic investigation. This will take place in collaboration with the SOC and will be subject to the approval of the PI.
- Develop a pipeline to extract frequencies or frequency properties from observed timeseries.
- Develop a pipeline to derive stellar properties from frequencies or frequency properties.
- Make available to the Project either a separate pipeline or other system to estimate stellar radius and/or identify giant stars, from power spectra based on long-cadence timeseries for cool giants. (Alternatively, at the discretion of the Project, use the power spectra provided by the SOC for these analyses.)
- Organize KASC to support these activities.
- Provide the selection of initial targets for asteroseismic program, as well as asteroseismic targets to be observed throughout the mission, for the Kepler Mission Planning.

# ***KAI Activities, after launch***

- Provide stellar parameters (particularly size) in a timely fashion to the Project; the goal is to provide the results in three months or less after receiving timeseries data.
- Perform asteroseismic analyses on any additional short-cadence targets upon request from the Project.
- Revise the asteroseismic target list as appropriate. In particular, identify cases suitable for asteroseismic analysis from those targets selected for short-cadence planet-transit observations.
- Comparison of the general stellar properties of cool MS stars with those of evolved stars.
- Ensure timely publication of the asteroseismic results.

# ***Resources provided by the Project***

- Provide access to time-series of 512 short-cadence targets chosen for asteroseismic analysis during the initial roll segment.
- Provide guaranteed access to 240 short-cadence targets available for change each quarter, for asteroseismic analyses throughout the mission. Of the 240 targets available for asteroseismology, at least 140 may be selected by the KAI, and up to 100 may be selected by the Project from transit candidate stars meeting brightness and spectral type criteria expected to allow asteroseismic results.
- Selection of 100 or more (as resources permit) long-cadence targets specifically for comparison with MS dwarfs. These can include cool giants to be observed for 4 years, beta Cephei stars, slowly pulsating B stars, and long-period delta Scuti stars.
- Verify and validate the proposed procedure for 'high-pass filtering' before launch.

# ***Required activities by Co-I Gilliland***

- Carry out the 'high-pass filtering' to remove transit information from data to be made available to asteroseismic investigation.
- 'High-pass filtered' data to be provided to KASOC, within one month after the data have been delivered to the DMC

# ***Management of the Asteroseismology Effort***

The activities of the KAI shall be overseen by a Steering Committee consisting of

- R. L. Gilliland (head, Kepler Co-I, STScI),
- T. M. Brown (Kepler Co-I, LCO),
- J. Christensen-Dalsgaard (Kepler Co-I, IFA),
- H. Kjeldsen (IFA)

Matters concerning data rights and publication will be dealt with by the Steering Committee of the KAI, in collaboration with the Project, as required.

# Kepler Asteroseismic Science Operation Centre

To manage the asteroseismic investigation, the Kepler Asteroseismic Science Operations Center shall be established at the Department of Physics and Astronomy, University of Aarhus. The establishment and activities of the KASOC will be covered from Danish funding through the duration of the proposed activities. No funding for non-US investigators is requested from the Project nor from NASA HQ for this investigation.

# ***Kepler Asteroseismic Science Consortium (KASC)***

To coordinate the many scientists that will participate in the asteroseismic study, the KASC shall be established immediately upon full signature of this letter. Relevant groups shall be invited to submit proposals for their participation in the KAI, including their contributions in the preparatory phase and the proposed use of the Kepler asteroseismic data. Based on these proposals, participants in the KASC shall be selected by the Steering Committee of the KAI, and individual agreements, consistent with the conditions stated in the present letter, shall be established between the KAI and these participants.

**These shall include a non-disclosure clause prohibiting any release of information about potential planetary transits that may inadvertently be present in the asteroseismic data, as well as any information that might inadvertently identify a potential planet host.**

# Non-disclosure agreement

The undersigned member of the Kepler Asteroseismic Science Consortium (KASC) recognizes that the data made available in the Kepler Asteroseismic Science Operations Centre (KASOC) are intended solely for the use for asteroseismology and that the data have been processed in such a way that all information about planetary transits should have been removed. Should indications suggesting the presence of a transit nonetheless emerge during analysis of the data, with this agreement I undertake not to reveal this information in any form, orally or in writing to anybody, with the exception of Kepler Col Ron Gilliland (gillil@stsci.edu) ; Gilliland will then discuss the result with the Kepler PI who will decide on further action.

Name and address:

Jørgen Christensen-Dalsgaard  
[etc.]



# Data access and publication policy

The KASC will be operated on the principle of open access to the Kepler asteroseismic data. A publication policy shall be established by the KAI in collaboration with the Project, consistent with the contributions made by the participants of the KASC to the specific results being published, and with due account being taken of the contributions of the Kepler Team. Papers based on the Kepler asteroseismic data shall be internally refereed before submission to a journal or preprint server.

**See talk by Ron Gilliland**

# ***Relation to guest-observer, participating-scientist, and data-analysis programs***

It is acknowledged that various community support programs may result from NASA Announcement of Opportunities to participate in the Kepler project, and/or obtain additional observations, and/or research support funding for utilization of Kepler data. Successful proposers with research relevant to asteroseismology have the option to apply to be associated with the KAI, as described in this letter.

US participants in the KAI/KASC may receive funding for asteroseismic investigations as allowed for in NASA research solicitations.

# Signatures

For the Kepler Project:

William J. Borucki

For the Kepler Asteroseismic Investigation:

Ronald L. Gilliland

For the Kepler Asteroseismic Science Operation Center:

Jørgen Christensen-Dalsgaard

# KASC steering committee

- Jørgen Christensen-Dalsgaard

# WP and ICD

- **Work Packages:** describe the tasks that individuals and research groups will do in relation to KASOC. Used to manage and control the work within KASC and KASOC
- **Interface Control Documents:** describe all requirements related to the interface between a given deliverable and the project (software, science management, hardware)

**More from Hans Kjeldsen later.**

# Work package

**KASC Work Package  
WP XXXX**

**Document no.:**

**KASOC/WP/XXXX(1)**

**Date:**

**XX.XX.2007**

**Prepared by:**

**Hans Kjeldsen representing KASOC**

**and**

**XXXXXX representing XXXXXX**

**Responsible for this WP:**

**XXXXXX**

# Interface control document

**KASC Interface Control Document  
ICD XXXX**

<b>Document no.:</b>	<b>KASOC/ICD/XXXXA,B,C..(1)</b>
<b>Date:</b>	<b>XX.XX.2007</b>
<b>Prepared by:</b>	<b>Hans Kjeldsen representing KASOC and</b>
<b>XXXXXX representing XXXXXX</b>	
<b>Related to Work Package:</b>	<b>KASOC/WP/XXXX</b>
<b>Related to Deliverable Item:</b>	<b>No. X</b>