HERSCHEL / Planck Project

Herschel Pointing Modes

(Annex I to SRS)

TABLE OF CONTENTS

Page No.

1 INTRODUCTION

Herschel / Planck is an ESA mission that combines the Herschel (previously called FIRST) and the Planck missions within one single programme.

The Herschel telescope (previously FIRST : Far Infrared and Sub-millimetre Telescope) is dedicated to perform astronomical observations in the far-infrared and sub-millimetre wavelength range. Herschel , the fourth European Space Agency (ESA) cornerstone mission is a multi-user observatory type mission. The detectors of the Herschel instruments have to be cooled to cryogenic temperatures in the range of 0.3 to 2K in order to reach the necessary sensitivity for the observation of a variety of weak radiation sources.

This document defines requirements for Herschel pointing modes to support Scientific Observations, in particular to make maps of extended objects, or to make high sensitivity measurements. This document is annex to the Herschel / Planck Satellite System Requirements Specification (SRS) SCI-PT-RS-05991.

2 RASTER POINTING

2.1 Normal raster pointing

Raster pointing is a series of fine pointing observations of equal duration (*t*), separated by slews, in order that the pointing of the telescope axis moves in a raster pattern as defined in Fig. 1. In this figure the following notations are used:

M is the number of pointings per line.

N is the number of lines.

d_1 is the spherical angular distance between successive steps.

d_2 is the spherical angular distance between successive lines.

In addition the inertial attitude of the pattern is defined by the quaternion Q_{rast} of the 1st raster point and an angle φ defining the rotation of the pattern axes with respect to local instrument axes.

The raster parameters, φ, M, N, d_1 and d_2 are within the following range and resolution:

φ: 0 – 180 degrees resolution: 0.1 degrees

M: 2 - 32

N: 1 - 32

d_1: 2 arcsec - 8 arcmin; resolution: 0.5 arcsec

d_2: 2 arcsec - 8 arcmin or 0; resolution: 0.5 arcsec

Note that d_2 being zero, means that it shall be possible to scan N times the points of a single line.

The duration of stable pointing at any position, *t*, will be between 10 seconds and 30 minutes.

2.2 Raster pointing with OFF-position

Raster pointing with OFF-position is a special form of raster pointing where, after a specified number of raster points (ON positions), the spacecraft slews to a predefined point (the OFF position), after which it resumes its raster pointing where it left the raster before going to the OFF position. The number of raster pointings (K) before going to the OFF position is determined by the timing characteristics of the raster pointing such that the time between each subsequent OFF position is less than some characteristic stability time of the instrument. This form of raster pointing is shown in Fig. 2.

For the ON positions, the raster is defined by the parameters Q_{rast}, φ, M, N, d_1 and d_2, with for each position an equal observation time *t*. The definition of these parameters is given above for normal raster pointing and its range and resolution are specified below.

The OFF position is defined by the parameter Q_{off}, specifying the quaternions of the OFF position in inertial coordinates.

K is the number of consecutive ON positions before going to the OFF position, and t_{off} is the time of stable pointing in the OFF position.

The pattern is followed line by line and where after each K ON positions the spacecraft moves to the OFF position. After each OFF position, the raster pointing shall be resumed for the next K ON positions, etc. (Fig. 2).

The raster parameters, φ, M, N, K, d_1 and d_2 are within the following range and resolution:

φ: 0 – 180 degrees resolution: 0.1 degrees

M: 2 - 32

N: 1 - 32

K: 2 - M x N

d_1: 2 arcsec - 8 arcmin; resolution: 0.5 arcsec

d_2: 2 arcsec - 8 arcmin or 0; resolution: 0.5 arcsec

The maximum value of K being equal to the total number of ON positions implies normal raster pointing with only a single OFF position pointing at completion of the raster.

Like for normal raster pointing, d_2 being zero means that it shall be possible to scan N times the points of a single line.

The duration of stable pointing at any position, t, will be between 10s and 30 minutes.

The spherical coordinates of the OFF position with respect to the centre of the map shall be within the following range:

d_{1off}: ±(0 arcmin - 2 degrees); d_{2off}: ±(0 arcmin - 2 degrees)

The duration t_{off}, of stable pointing in the OFF position is within the range 10 s to 30 min.

3 LINE SCANNING

3.1 Normal line scanning

This is a scanning mode along short parallel lines, such that the telescope axis moves as shown in Fig.3 with parameters as defined below:

N is the number of lines.

D_1 is the angular extent of the lines.

d_2 is the angular distance between successive lines.

The inertial attitude of the pattern is defined by the quaternions Q_{scan} of the beginning of the 1st scan line and an angle φ defining the rotation of the scan lines with respect to local instrument axes.

The pattern shall be followed line by line in the way shown by the arrows in Fig. 3.

The scan parameters, φ, N, D_1 and d_2 are within the following range and resolution:

φ: 0 – 180 degrees resolution: 0.1 degrees

N: 1 - 32

D_1: 20 arcsec - 20 deg; resolution: 5 arcsec

d_2: 2 arcsec - 8 arcmin or 0; resolution: 0.5 arcsec

Note that the minimum of d_2 being zero, means that it shall be possible to scan N times the same line

The scan rate, r, shall be changeable by ground command and will be between 0.1 arcsec/s and 1 arcmin/s with a resolution of 0.1 arcsec/s.

3.2 Line scanning with OFF-position

Line scanning with OFF-position is a special form of line scanning where, after a specified number of lines, the spacecraft slews to a predefined point (the OFF position), after which it resumes its line scanning where it left the pattern before going to the OFF position. The number of lines (K) before going to the OFF position is determined by the timing characteristics of the operation such that the time between each subsequent OFF position is less than some characteristic stability time of the instrument. This form of line scanning is shown in Fig. 4.

The line scan pattern is defined by the parameters Q_{scan}, φ, N, D_1 and d_2 as given above.

The OFF position is defined by the parameter Q_{off}, specifying the quaternions of the OFF position in inertial coordinates.

K is the number of consecutive lines before going to the OFF position, and t_{off} is the time of stable pointing in the OFF position.

The pattern shall be followed line by line in the way shown by the arrows in Fig. 4 and where after each K lines the spacecraft moves to the OFF position. After each OFF position, the line scanning shall be resumed for the next K lines, etc.

The scan parameters, φ, N, D_1 and d_2 are command within the following range and resolution:

φ: 0 – 180 degrees resolution: 0.1 degrees

N: 1 - 32

K: 1 - N

D_1: 20 arcsec - 2 deg; resolution: 5 arcsec

d_2: 2 arcsec - 8 arcmin or 0; resolution: 0.5 arcsec

The maximum value of K being equal to the total number of lines implies normal line scanning with only a single OFF position pointing at completion of the line pattern.

The scan rate, r, is between 0.1 arcsec/s and 1 arcmin/s with a resolution of 0.1 arcsec/s.

The spherical coordinates of the OFF position with respect to the centre of the map shall be within the following range:

d_{1off}: $\pm$(0 arcmin - 2 degree);

d_{2off}: $\pm$(0 arcmin - 2 degree)

The duration t_{off}, of stable pointing in the OFF position is within the range 10 s to 30 min.

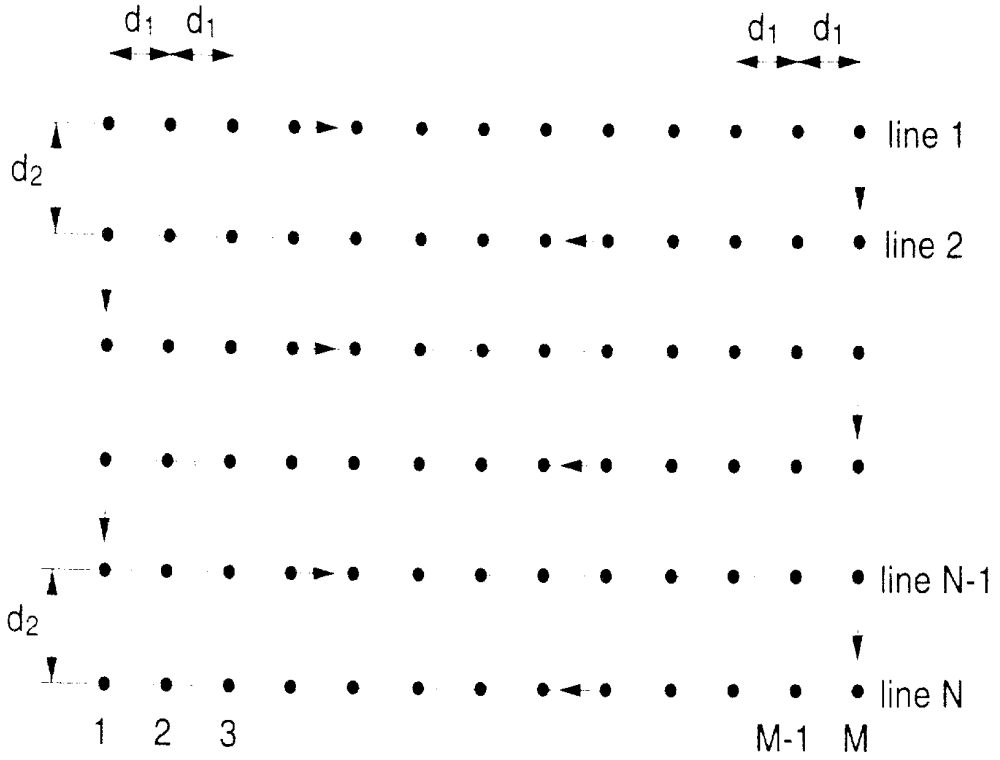

Figure 1 NORMAL RASTER POINTING

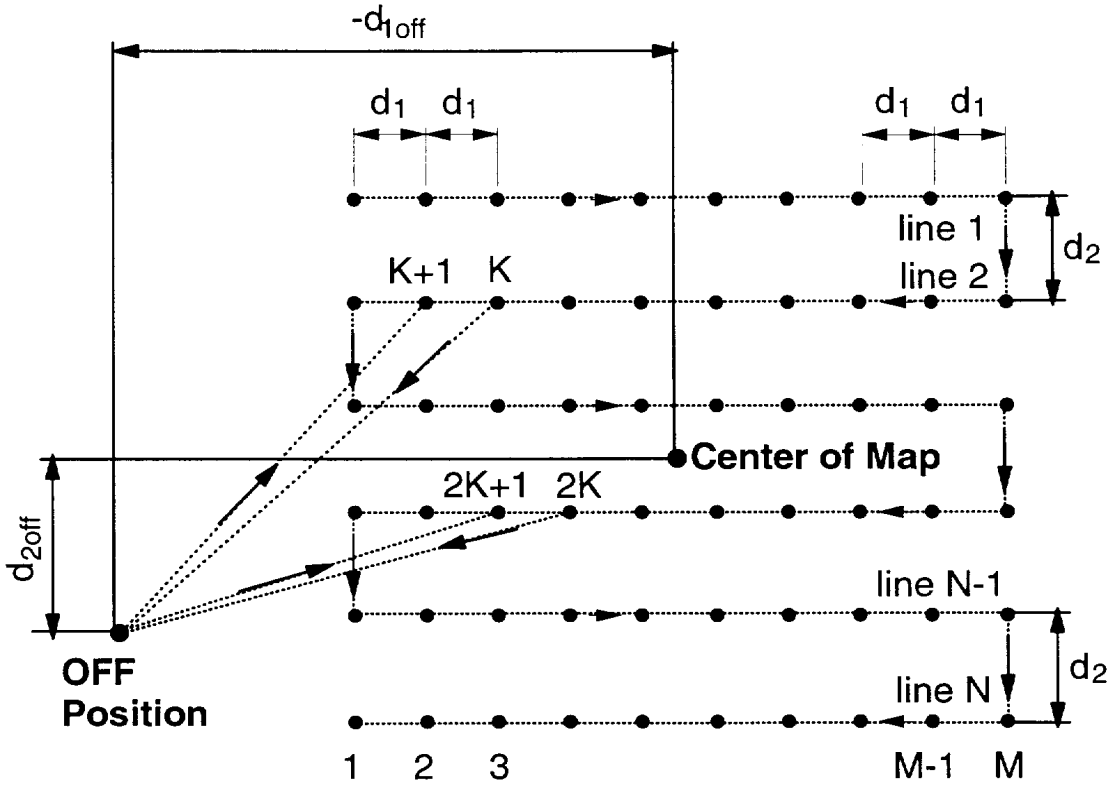

Figure 2 RASTER POINTING WITH OFF-POSITION

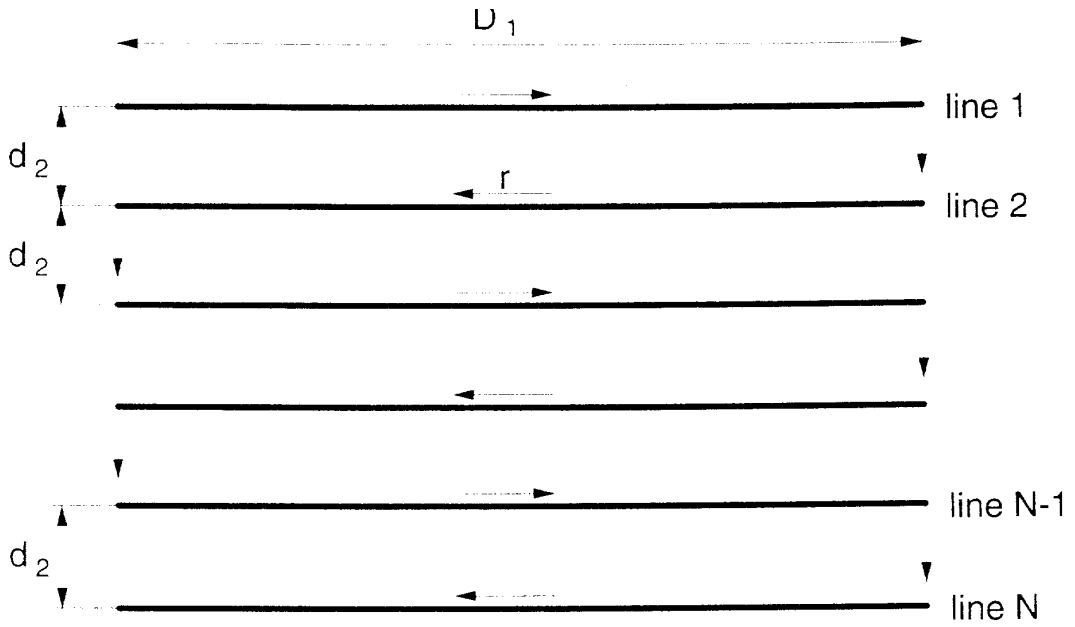

Figure 3 NORMAL LINE SCANNING

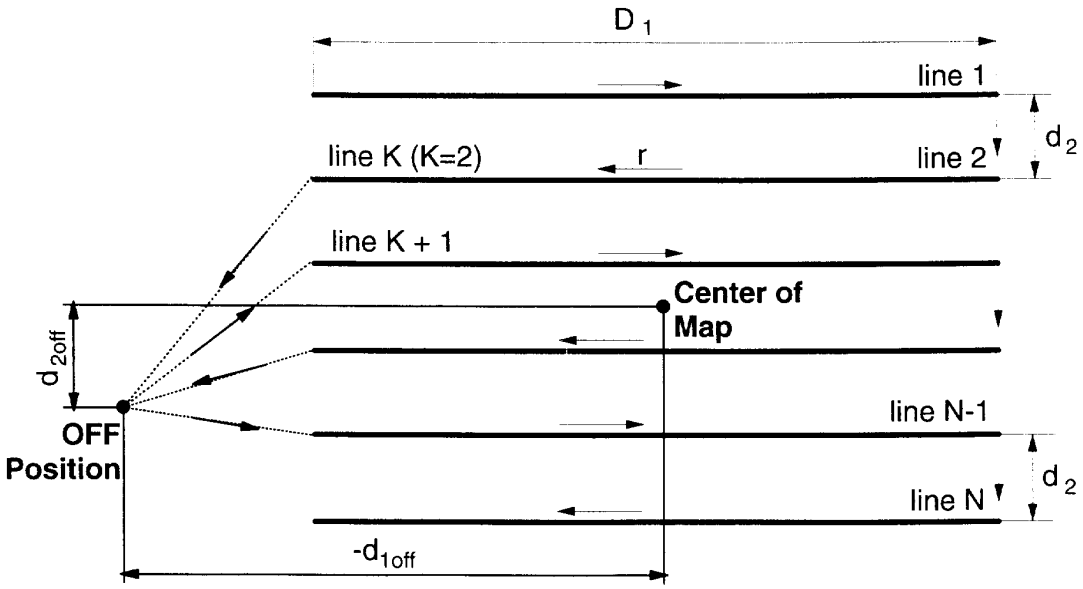

FIGURE 4 LINE SCANNING WITH OFF-POSITION

4 TRACKING OF SOLAR SYSTEM OBJECTS

The satellite shall be able to follow, by ground commanded tables of coefficients of Chebyshev polynoms, objects such as planets, comets, etc. having a maximum speed relative to the tracking star of 10 arcsec/min.

The trajectory of such solar system object will be described by Chebyshev polynomials of at least 3rd order.

The attitude defining the raster (Q_{rast}) (for raster, position switching or nodding) and line scan patterns (Q_{scan}) shall also be possible reference to a solar system object, i.e. the whole pattern moves with the solar system object.

5 POSITION SWITCHING

Position switching is an observing mode in which the instrument line of sight is periodically changed between a target source and a position off the source.

Periodically the telescope pointing direction is changed between a target source and some position off the source.

This is a special case of normal raster pointing with the following raster parameters:

φ: 0 – 180 degrees resolution: 0.1 degrees

M: 2

N: 1 - n

d_1: 2 arcsec – 2 deg; resolution: 0.5 arcsec

d_2: 0

The integration times in the "on" and "off" positions are within the range of 10 s to 20 min (depending on the throw).

6 NODDING

Nodding is an observing mode in which the target source is moved from one instrument chop position to the other chop position. In this case the pointing direction will change in the direction of the instrument chopper throw.

Periodically the telescope pointing direction is changed such that the source is moved from one instrument chop position to the other position.

This is a special case of normal raster pointing with the following raster parameters:

φ: 0

M: 2

N: 1 - n

d_1: 2 arcsec – 16 arcmin; resolution: 0.5 arcsec

d_2: 0

The integration times in both positions are equal and are within the range of 10 s to 20 min (depending on the throw).