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Edwin F. Erickson, Kevin Krisciunas, and
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Peaker: An Automatic Boresight Peaking Routine for the C-141 Telescope

Edwin F. Erickson, Ames Research Center, Moffett Field, California
Kevin Krisciunas
Thomas Mathieson, Informatics, Inc., Palo Alto, California

National Aeronautics and Space Administration

Ames Research Center
Moffett Field, California 94035

SUMMARY

This report describes the operation of an automated procedure which maximizes the signal from a detector mounted on the telescope of the Kuiper Airborne Observatory by pointing the telescope at an astronomical source.

INTRODUCTION

In the measurement of discrete astronomical objects it is necessary to orient the telescope to maximize the signal from a detector mounted at the focal plane. The low frequency stability of the 91 cm telescope of the Kuiper Airborne Observatory (KAO) is derived from a video image of a guide star formed in a 15 cm "tracker" telescope which is attached to the main telescope. The relationship of the position viewed by the investigator's detector and the visual field of view of either the main telescope or the tracker telescope is called the boresight. The position of the guide star within the tracker field of view and the attitude of the tracker telescope relative to the main telescope can be varied to permit offset guiding on bright stars when the object of interest is too faint to be tracked. The PEAKER program utilizes the signal from the investigator's detector, the Tracker Computer, and the Executive Computer of the KAO to automatically maximize the signal from the detector by orienting the telescope in a closed loop mode while tracking on a guide star. The necessity for peaking the boresight more than once per object is due to variations in the boresight position, which may be caused by telescope flexure, chopper drifts, etc., although the most common cause is probably field rotation of the guide star while offset guiding. Depending on the application, boresight peaking may be desirable every few minutes.

CONCEPT

PEAKER follows a sequence which is similar to that of an experimenter optimizing the boresight. The objective is to move the telescope under computer control to maximize the infrared signal quickly. The signal is an analog voltage V; $|V|<10$ volts. The elevation and azimuth axes of the telescope motion are labelled x and y. Then $V = V(x,y)$. The philosophy of the peaking routine is to optimize in one dimension (x), then optimize in the other dimension, and then repeat the optimization in both axes at the experimenter's discretion. The computer samples V at different points (x,y), computes the optimum position (X,Y), and moves the telescope to (X,Y).

INITIALIZATION

Prior to using the peaking program, the experimenter will define the input parameters:

T = integration time for one sample (default: T = 1 second); the voltage V is sampled roughly every 0.01 seconds during T. After moving to a new position, PEAKER automatically allows for settling of the telescope before sampling V.

S = angular separation of sample points for start of peaking (default S = 15"); S should be $\lesssim$ FWHM/2 of the experimenter's beam profile.

B = size of the box into which the telescope must be pointed prior to sampling V. The default box dimensions are one tracker pixel in elevation (2".9) and one tracker pixel in azimuth (4".3). Fractional pixels can be specified for B.

L = limit of search range (default L = 60").

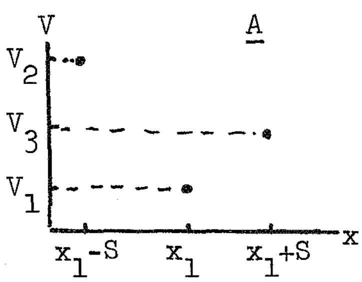
These parameters are entered into the Executive Computer.

PROCEDURE

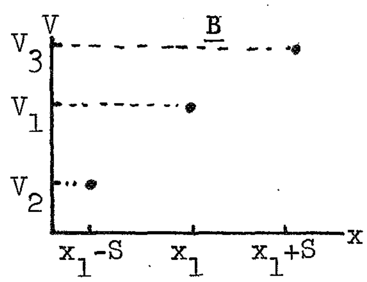
The experimenter finds some signal by moving the telescope with the "tweaker box" and tells the tracker operator "let's maximize (minimize) the signal starting at this position." The operator pushes the "Maximize" ("Minimize") switch on the Tracker Console.

PROGRAM OPERATION

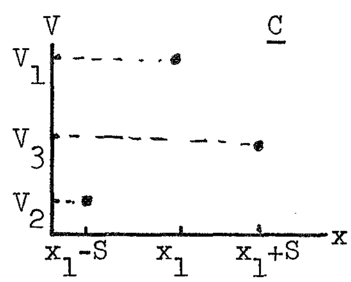
I. Let the initial coordinates be labelled x_1, y_1. The program measures V at this position, and at two adjacent positions in x. One of the following conditions will obtain:



$V_1 < V_2$ and $V_1 < V_3$



$V_3 < V_1 < V_2$
(or, $V_2 < V_1 < V_3$)

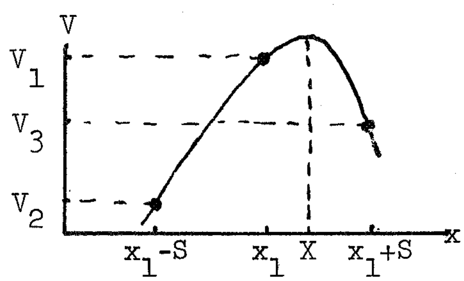


$V_1 > V_2$ and $V_1 > V_3$

If condition A occurs, something is wrong (if maximum is being sought). The program halts and the experimenter told to try again.

If B occurs, the program moves the telescope by S, redefines x_1, samples V, and repeats until condition C is established.

As soon as condition C exists, the computer finds the position of the maximum of a parabola fitted through the last three points measured:



$$V_1 = V(x_1, y_1)$$
$$V_2 = V(x_1 - S, y_1)$$
$$V_3 = V(x_1 + S, y_1)$$

$$X = x_1 + \frac{S}{2}\left(\frac{V_3 - V_2}{2V_1 - V_2 - V_3}\right)$$

Note that S must be small enough that V_2 and V_3 represent appreciable signal from the source.

II. The program then returns to Step I, but maximizes in the y coordinate while using $x = X$. The result is

$$V_4 = V(X, y_1)$$
$$V_5 = V(X, y_1 - S)$$
$$V_6 = V(X, y_1 + S)$$

and a position $y = Y$, obtained from an equation similar to that for X above.

III. The program finally positions the telescope at X and Y, and a light on the tracker console indicates that PEAKER is done.

IV. If the experimenter is not satisfied, he asks the tracker operator to restart PEAKER or the ADAMS operator to reinitialize the parameters.

REMARKS

Thus there are two commands which are accomplished with the switches on the Tracker Console: MAXIMIZE/MINIMIZE. If PEAKER fails it is usually because of incorrect parameters, which can be quickly modified to improve the performance. In operation with the chopper, PEAKER is usually started immediately after beam switching. The tracker computer will remember the new position (X, Y) found by PEAKER if the appropriate beam STORE switch on the Tracker Console is pushed.

The option to abort during PEAKER operation is provided. This provision returns control to the regular tracker program. For example, if loss of track occurs during the operation of the peaking routine, it would normally be aborted.

In practice PEAKER finds an optimum boresight in about 12 seconds using the default parameters. Smaller values of S and T will generally result in shorter optimization times. However, the settling time of $\sim$ 5 seconds is determined from the stability of telescope, and may be longer in turbulent operating conditions, or if B is decreased.

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16. Abstract

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