Automatic recognition and removal of cosmic rays on Deep Impact CCDs

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In order to obtain better quality of images, the glitches of cosmic rays (CRs) must be removed from the images. Images made by different cameras (HRI, MRI, and ITS) during the flight of Deep Impact to Comet Tempel 1 were studied. We analyzed the work of several codes (*imgclean*, *crfind*, and *di_crrej*) written by several authors and recognizing CRs on one image. These codes run well for normal sky calibrated images, but usually they do not work well with raw images, some of the codes have problems with infrared images and with long (oblique entry) rays, and they can mistakenly recognize some pixels near the edge of a comet as CRs. We have developed an algorithm which allows one to recognize most CRs using only one CCD image and which works both with raw and calibrated images. In some cases (e.g., for removal of CRs near a bright star), it works better than the above codes, but for many calibrated images it has no advantages. After the work of our code, pixels of deleted CRs look like neighboring pixels. *Crfind* and *di_crrej* only find pixels corresponding to CRs. *Imgclean* does not replace correctly pixels near the edge of a comet, so we have changed the replacement in *imgclean*. Analysis of different dark and normal sky visual images showed that for exposure time t>4 s most clusters on an image consist of not more than 4 pixels and these clusters are caused mainly by hits of CRs. Glitches of large rays have a linear form in contrast to the more circular form for stars. For most HRI and MRI visual images made during low solar activity at t>4 s, the number N_{sc} of clusters on an image per second per square centimeter of CCD was about 2-4, both for dark and normal sky images, and mainly there were no glitches of CRs consisting of more than $2t$ pixels, where t is in seconds. At high solar activity, N_{sc} sometimes exceeded 10. The ratio of the number of CRs consisting of n pixels obtained at high solar activity to that at low solar activity was greater for greater n, e.g., it was about 1-2 for n=1 and about 4-10 at n=5. Due to higher variations of brightness of background, at default parameter settings, none of the codes considered worked well with calibrated dark ITS images. Clusters consisted of less that 4 pixels, usually can not be surely identified as CRs on ITS CCDs at any parameters, as the brightness of such small CRs is low enough. For infrared images, *imgclean* has less problems than other codes, but for these images it is needed to check whether the clusters detected as CRs are not located close to dark or bright bad pixels, else the number of clusters detected as CRs is by a factor of several greater than the actual number of CRs.