Discovering the missing 2.2<z<3 quasars by combining optical variability and optical/near-IR colors

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The identifications of quasars in the redshift range 2.2<z<3 are known to be very inefficient as their optical colors are indistinguishable from those of stars. Recent studies have proposed to use optical variability or near-IR colors to improve the identifications of the missing quasars in this redshift range. Here we present a case study by combining both factors. We select a sample of 70 quasar candidates from variables in SDSS Stripe 82, which are non-UV excess sources and have UKIDSS near-IR public data. They are clearly separated into two parts on the Y-K/g-z color-color diagram, and 59 of them meet or lie close to a newly proposed Y-K/g-z selection criterion for z<4 quasars. 44 of these 59 sources have been previously identified as quasars in SDSS DR7, and 35 among them are quasars at 2.2<z<3. We present spectroscopic observations of 14 of 15 remaining quasar candidates using the Bok 2.3m telescope and the MMT 6.5m telescope, and successfully identify all of them as new quasars at z=2.36 to 2.88. We also apply this method to a sample of 643 variable quasar candidates with SDSS-UKIDSS nine-band photometric data selected from 1875 new quasar candidates in SDSS Stripe 82 given by Butler & Bloom based on the time-series selections, and find that 188 of them are probably new quasars with photometric redshifts at 2.2<z<3. Our results indicate that the combination of optical variability and optical/near-IR colors is probably the most efficient way in finding 2.2<z<3 quasars and very helpful for constructing a complete quasar sample. We discuss its implications to the ongoing and upcoming large optical and near-IR sky surveys.

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