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On a relationship between record times and record values of an i.i.d. sequence

Let $\{X_n\}$ be an i.i.d. sequence of random variables with a continuous c.d.f. F. Define upper and lower record times by

$$U_0 = 1, \qquad U_{n+1} = \inf\{k;\, X_k > X_{U_n}\}; \qquad n \geqq 0;$$
$$L_0 = 1, \qquad L_{n+1} = \inf\{k;\, X_k < X_{L_n}\}; \qquad n \geqq 0.$$

If F is the c.d.f. of an exponential distribution with unit mean, then we have the following result.

Theorem. (a) L_n and $L_nX_{L_n}$ are independent for all $n \geqq 0$.
(b) $L_nX_{L_n}$ is exponentially distributed with unit mean.

This theorem allows the following conclusion.

Corollary. (a) $X_{U_n} - \log U_n$ is asymptotically Λ-distributed for $n \to \infty$ where Λ denotes the c.d.f. of a doubly-exponentially distributed random variable.

(b) $\log U_n = X_{U_n} + O(\log n)$ a.s. $(n \to \infty)$.

Similar results can be derived also for the case of a general c.d.f. F, as well as strong approximations jointly for record times, inter-record times and record values by Poisson and Wiener processes.