



- (51) **International Patent Classification:**
G06N 10/00 (2019.01) *B82Y 10/00* (2011.01)
- (21) **International Application Number:**
PCT/IB2021/053222
- (22) **International Filing Date:**
19 April 2021 (19.04.2021)
- (25) **Filing Language:** English
- (26) **Publication Language:** English
- (30) **Priority Data:**
63/014,066 22 April 2020 (22.04.2020) US
- (71) **Applicant: GOLDMAN SACHS & CO. LLC** [US/US];
200 West Street, New York, New York 10282 (US).
- (72) **Inventor: ZENG, William;** Goldman Sachs & Co. LLC,
200 West Street, New York, New York 10282 (US).
- (74) **Agent: BROWNSTONE, Daniel et al.;** Fenwick & West
LLP, 902 Broadway, Suite 14, New York, New York 10010
(US).
- (81) **Designated States** (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, IT, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS, ZA, ZM, ZW.
- (84) **Designated States** (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ,

(54) **Title:** ASYNCHRONOUS QUANTUM INFORMATION PROCESSING

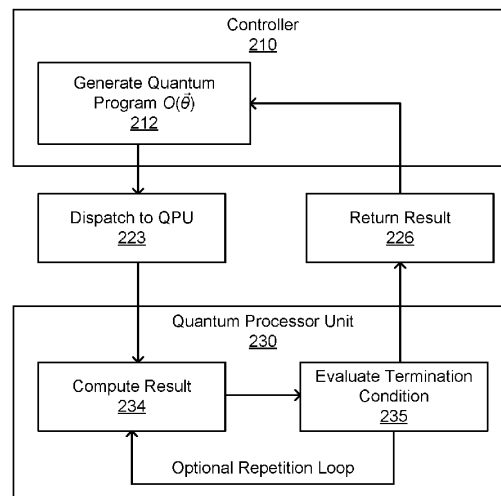


FIG. 2

(57) **Abstract:** An asynchronous approach to implementing a quantum algorithm can reduce dead time of a quantum information processing unit (QIPU). Multiple parameter sets are determined for a quantum program by a controller and the QIPU is instructed to execute the quantum program for the parameter sets. Results from each program execution are returned to the controller. After one or more results are received, the controller determines an updated parameter set while the QIPU continues executing the quantum program for the remaining parameter sets. The QIPU is instructed to execute the quantum program for the updated parameter set (e.g., immediately, after a current program execution, or after the remaining parameter sets are processed). This asynchronous approach can result in the QIPU having little or no dead time, and thus can make more efficient use of the QIPU.

[Continued on next page]

TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

- *with international search report (Art. 21(3))*
- *in black and white; the international application as filed contained color or greyscale and is available for download from PATENTSCOPE*