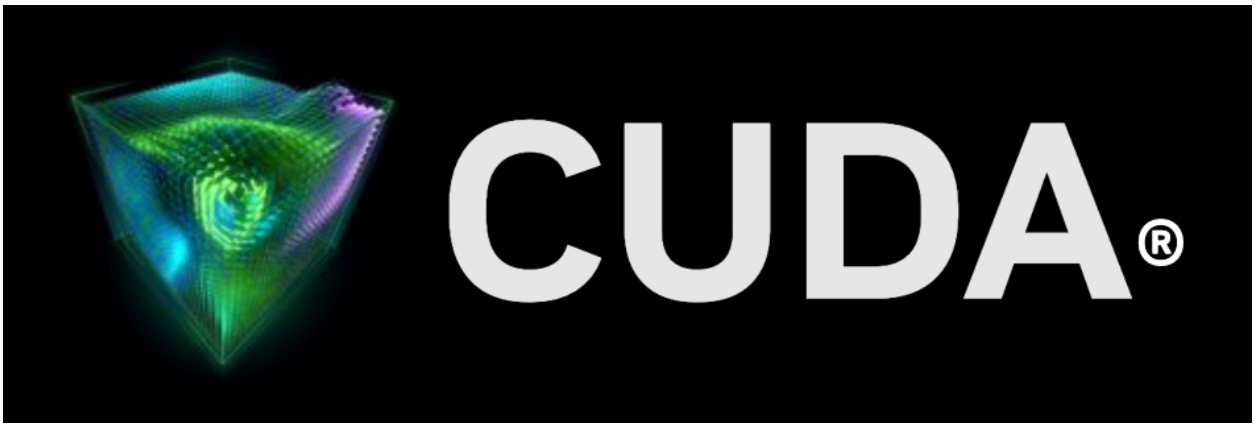

Release Notes

Release 12.0

NVIDIA

Jan 28, 2023

Contents

NVIDIA CUDA Toolkit Release Notes

The Release Notes for the CUDA Toolkit.

The release notes for the NVIDIA® CUDA® Toolkit can be found online at https://docs.nvidia.com/cuda/cuda-toolkit-release-notes/index.html.

Note: The release notes have been reorganized into two major sections: the general CUDA release notes, and the CUDA libraries release notes including historical information for 12.x releases.

Chapter 1. CUDA Toolkit Major Component Versions

CUDA Components Starting with CUDA 11, the various components in the toolkit are versioned independently.

For CUDA 12.0 Update 1, the table below indicates the versions:

Table 1: Table 1. CUDA 12.0 Update 1 Component Versions

Component Name		Version Information	Supported Architectures	Supported Platforms
CUDA C++ Core Compute Libraries	Thrust	2.0.1	x86_64, POWER, aarch64-jetson	Linux, Windows
	CUB	2.0.1		
	libcu++	1.9.0		
	Cooperative Groups	12.0.0		
CUDA Compatibility		12.0.32271208	x86_64, POWER, aarch64-jetson	Linux, Windows
CUDA Runtime (cudart)		12.0.146	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
cuobjdump		12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows
CUPTI		12.0.146	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuxxfilt (demangler)		12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows
CUDA Demo Suite		12.0.140	x86_64	Linux, Windows
CUDA GDB		12.0.140	x86_64, POWER, aarch64-jetson	Linux, WSL
CUDA Nsight Eclipse Plugin		12.0.140	x86_64, POWER	Linux
CUDA NVCC		12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL

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Table 1 – continued from previous page

Component Name	Version Information	Supported Architectures	Supported Platforms
CUDA nvdisasm	12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows
CUDA NVML Headers	12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA nvprof	12.0.146	x86_64, POWER	Linux, Windows
CUDA nvprune	12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA NVRTC	12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
NVTX	12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA NVVP	12.0.146	x86_64, POWER	Linux, Windows
CUDA OpenCL	12.0.140	x86_64	Linux, Windows
CUDA Profiler API	12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA Compute Sanitizer API	12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuBLAS	12.0.2.224	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuDLA	12.0.140	aarch64-jetson	Linux
CUDA cuFFT	11.0.1.95	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuFile	1.5.1.14	x86_64	Linux
CUDA cuRAND	10.3.1.124	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuSOLVER	11.4.3.1	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA cuSPARSE	12.0.1.140	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA NPP	12.0.1.104	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA nvJitLink	12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA nvJPEG	12.0.1.102	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
CUDA NVVM Samples	12.0.140	x86_64, POWER, aarch64-jetson	Linux, Windows

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Table 1 – continued from previous page

Component Name	Version Information	Supported Architectures	Supported Platforms
Nsight Compute	2022.4.1.6	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL (Windows 11)
Nsight Systems	2022.4.2.50	x86_64, POWER, aarch64-jetson	Linux, Windows, WSL
Nsight Visual Studio Edition (VSE)	2022.4.1.23005	x86_64 (Windows)	Windows
nvidia_fs[1]	2.14.14	x86_64, aarch64-jetson	Linux
Visual Studio Integration	12.0.140	x86_64 (Windows)	Windows
NVIDIA Linux Driver	525.85.12	x86_64, POWER, aarch64-jetson	Linux
NVIDIA Windows Driver	528.33	x86_64 (Windows)	Windows, WSL

CUDA Driver Running a CUDA application requires the system with at least one CUDA capable GPU and a driver that is compatible with the CUDA Toolkit. See Table 3. For more information various GPU products that are CUDA capable, visit https://developer.nvidia.com/cuda-gpus.

Each release of the CUDA Toolkit requires a minimum version of the CUDA driver. The CUDA driver is backward compatible, meaning that applications compiled against a particular version of the CUDA will continue to work on subsequent (later) driver releases.

More information on compatibility can be found at https://docs.nvidia.com/cuda/cuda-c-best-practices-guide/index.html#cuda-compatibility-and-upgrades.

Note: Starting with CUDA 11.0, the toolkit components are individually versioned, and the toolkit itself is versioned as shown in the table below.

The minimum required driver version for CUDA minor version compatibility is shown below. CUDA minor version compatibility is described in detail in https://docs.nvidia.com/deploy/cuda-compatibility/index.html

[1] Only available on select Linux distros

Table 2: Table 2. CUDA Toolkit and Minimum Required Driver Version for CUDA Minor Version Compatibility

CUDA Toolkit	Minimum Required Driver Version for CUDA Minor Version Compatibility*	
	Linux x86_64 Driver Version	Windows x86_64 Driver Version
CUDA 12.0.x	>=525.60.13	>=527.41
CUDA 11.8.x	>=450.80.02	>=452.39
CUDA 11.7.x	>=450.80.02	>=452.39
CUDA 11.6.x	>=450.80.02	>=452.39
CUDA 11.5.x	>=450.80.02	>=452.39
CUDA 11.4.x	>=450.80.02	>=452.39
CUDA 11.3.x	>=450.80.02	>=452.39
CUDA 11.2.x	>=450.80.02	>=452.39
CUDA 11.1 (11.1.0)	>=450.80.02	>=452.39
CUDA 11.0 (11.0.3)	>=450.36.06**	>=451.22**

* Using a Minimum Required Version that is **different** from Toolkit Driver Version could be allowed in compatibility mode – please read the CUDA Compatibility Guide for details.

** CUDA 11.0 was released with an earlier driver version, but by upgrading to Tesla Recommended Drivers 450.80.02 (Linux) / 452.39 (Windows), minor version compatibility is possible across the CUDA 11.x family of toolkits.

The version of the development NVIDIA GPU Driver packaged in each CUDA Toolkit release is shown below.

Table 3: Table 3. CUDA Toolkit and Corresponding Driver Versions

CUDA Toolkit	Toolkit Driver Version	
	Linux x86_64 Driver Version	Windows x8
CUDA 12.0 Update 1	>=525.85.12	>=528.33
CUDA 12.0 GA	>=525.60.13	>=527.41
CUDA 11.8 GA	>=520.61.05	>=520.06
CUDA 11.7 Update 1	>=515.48.07	>=516.31
CUDA 11.7 GA	>=515.43.04	>=516.01
CUDA 11.6 Update 2	>=510.47.03	>=511.65
CUDA 11.6 Update 1	>=510.47.03	>=511.65
CUDA 11.6 GA	>=510.39.01	>=511.23
CUDA 11.5 Update 2	>=495.29.05	>=496.13
CUDA 11.5 Update 1	>=495.29.05	>=496.13

cont

Table 3 – continued from previous page

CUDA Toolkit	Toolkit Driver Version	
CUDA 11.5 GA	>=495.29.05	>=496.04
CUDA 11.4 Update 4	>=470.82.01	>=472.50
CUDA 11.4 Update 3	>=470.82.01	>=472.50
CUDA 11.4 Update 2	>=470.57.02	>=471.41
CUDA 11.4 Update 1	>=470.57.02	>=471.41
CUDA 11.4.0 GA	>=470.42.01	>=471.11
CUDA 11.3.1 Update 1	>=465.19.01	>=465.89
CUDA 11.3.0 GA	>=465.19.01	>=465.89
CUDA 11.2.2 Update 2	>=460.32.03	>=461.33
CUDA 11.2.1 Update 1	>=460.32.03	>=461.09
CUDA 11.2.0 GA	>=460.27.03	>=460.82
CUDA 11.1.1 Update 1	>=455.32	>=456.81
CUDA 11.1 GA	>=455.23	>=456.38
CUDA 11.0.3 Update 1	>= 450.51.06	>= 451.82
CUDA 11.0.2 GA	>= 450.51.05	>= 451.48
CUDA 11.0.1 RC	>= 450.36.06	>= 451.22
CUDA 10.2.89	>= 440.33	>= 441.22
CUDA 10.1 (10.1.105 general release, and updates)	>= 418.39	>= 418.96
CUDA 10.0.130	>= 410.48	>= 411.31
CUDA 9.2 (9.2.148 Update 1)	>= 396.37	>= 398.26
CUDA 9.2 (9.2.88)	>= 396.26	>= 397.44
CUDA 9.1 (9.1.85)	>= 390.46	>= 391.29
CUDA 9.0 (9.0.76)	>= 384.81	>= 385.54
CUDA 8.0 (8.0.61 GA2)	>= 375.26	>= 376.51
CUDA 8.0 (8.0.44)	>= 367.48	>= 369.30
CUDA 7.5 (7.5.16)	>= 352.31	>= 353.66
CUDA 7.0 (7.0.28)	>= 346.46	>= 347.62

For convenience, the NVIDIA driver is installed as part of the CUDA Toolkit installation. Note that this driver is for development purposes and is not recommended for use in production with Tesla GPUs.

For running CUDA applications in production with Tesla GPUs, it is recommended to download the latest driver for Tesla GPUs from the NVIDIA driver downloads site at https://www.nvidia.com/drivers.

During the installation of the CUDA Toolkit, the installation of the NVIDIA driver may be skipped on Windows (when using the interactive or silent installation) or on Linux (by using meta packages).

For more information on customizing the install process on Windows, see https://docs.nvidia.com/

cuda/cuda-installation-guide-microsoft-windows/index.html#install-cuda-software.

For meta packages on Linux, see https://docs.nvidia.com/cuda/cuda-installation-guide-linux/index.html#package-manager-metas.

Chapter 2. New Features

This section lists new general CUDA and CUDA compilers features.

2.1. General CUDA

12.0

- CUDA 12.0 exposes programmable functionality for many features of the Hopper and Ada Lovelace architectures:
  - Many tensor operations now available via public PTX:
    - TMA operations
    - TMA bulk operations
    - 32x Ultra xMMA (including FP8/FP16)
  - Membar domains in Hopper, controlled via launch parameters
  - Support Hopper asynchronous transaction barrier in C++ and PTX
  - Introduced C intrinsics for Cooperative Grid Array (CGA) relaxed barrier support
  - Programmatic L2 Cache to SM multicast (Hopper-only)
  - Public PTX for SIMT collectives - elect_one
  - Genomics/DPX instructions now available for Hopper GPUs to provide faster combined-math arithmetic operations (three-way max, fused add+max, etc.)
- Enhancements to the CUDA graphs API:
  - You can now schedule graph launches from GPU device-side kernels by calling built-in functions. With this ability, user code in kernels can dynamically schedule graph launches, greatly increasing the flexibility of CUDA graphs.
  - The `cudaGraphInstantiate()` API has been refactored to remove unused parameters.
- Added the ability to use virtual memory management (VMM) APIs such as `cuMemCreate()` with GPUs masked by `CUDA_VISIBLE_DEVICES`.
- Application and library developers can now programmatically update the priority of CUDA streams.
- CUDA 12.0 adds support for revamped CUDA Dynamic Parallelism APIs, offering substantial performance improvements vs. the legacy CUDA Dynamic Parallelism APIs.

- Added new APIs to obtain unique stream and context IDs from user-provided objects:
  - `cuStreamGetId(CUstream hStream, unsigned long long *streamId)`
  - `cuCtxGetId(CUcontext ctx, unsigned long long *ctxId)`
- Added support for read-only `cuMemSetAccess()` flag `CU_MEM_ACCESS_FLAGS_PROT_READ`.

2.2. CUDA Compilers

12.0

- JIT LTO support is now officially part of the CUDA Toolkit through a separate nvJitLink library. A technical deep dive blog will go into more details. Note that the earlier implementation of this feature has been deprecated. Refer to the Deprecation/Dropped Features section below for details.
- New host compiler support:
  - GCC 12.1 (Official) and 12.2.1 (Experimental)
  - VS 2022 17.4 Preview 3 fixes compiler errors mentioning an internal function `std::_Bit_cast` by using CUDA's support for `__builtin_bit_cast`.
- NVCC and NVRTC now support the c++20 dialect. Most of the language features are available in host and device code; some such as coroutines are not supported in device code. Modules are not supported for both host and device code. Host Compiler Minimum Versions: GCC 10, Clang 11, VS2022, Arm C/C++ 22.x. Refer to the individual Host Compiler documentation for other feature limitations. Note that a compilation issue in C++20 mode with <complex> header mentioning an internal function `std::_Bit_cast` is resolved in VS2022 17.4.
- NVRTC default C++ dialect changed from C++14 to C++17. Refer to the ISO C++ standard for reference on the feature set and compatibility between the dialects.
- NVVM IR Update: with CUDA 12.0 we are releasing NVVM IR 2.0 which is incompatible with NVVM IR 1.x accepted by the libNVVM compiler in prior CUDA toolkit releases. Linking of NVVM IR Version 1.11 with 2.0 will result in a compiler error. Users of the libNVVM compiler in CUDA 12.0 toolkit must generate NVVM IR 2.0.

2.3. CUDA Developer Tools

- For changes to nvprof and Visual Profiler, see the changelog.
- For new features, improvements, and bug fixes in CUPTI, see the changelog.
- For new features, improvements, and bug fixes in Nsight Compute, see the changelog.
- For new features, improvements, and bug fixes in Compute Sanitizer, see the changelog.
- For new features, improvements, and bug fixes in CUDA-GDB, see the changelog.

Chapter 3. Deprecated or Dropped Features

Features deprecated in the current release of the CUDA software still work in the current release, but their documentation may have been removed, and they will become officially unsupported in a future release. We recommend that developers employ alternative solutions to these features in their software.

General CUDA

- CentOS Linux 8 reached End-of-Life on December 31, 2021. Support for this OS is now removed from the CUDA Toolkit and is replaced by Rocky Linux 8.
- Server 2016 support has been deprecated and shall be removed in a future release.
- Kepler architecture support is removed from CUDA 12.0.
- CUDA 11 applications that relied on Minor Version Compatibility are not guaranteed to work in CUDA 12.0 onwards. Developers will either need to statically link their applications, or recompile within the CUDA 12.0 environment to ensure continuity of development.
- From 12.0, JIT LTO support is now part of CUDA Toolkit. JIT LTO support in the CUDA Driver through the cuLink driver APIs is officially deprecated. Driver JIT LTO will be available only for 11.x applications. The following enums supported by the cuLink Driver APIs for JIT LTO are deprecated:
  - `CU_JIT_INPUT_NVVM`
  - `CU_JIT_LTO`
  - `CU_JIT_FTZ`
  - `CU_JIT_PREC_DIV`
  - `CU_JIT_PREC_SQRT`
  - `CU_JIT_FMA`
  - `CU_JIT_REFERENCED_KERNEL_NAMES`
  - `CU_JIT_REFERENCED_KERNEL_COUNT`
  - `CU_JIT_REFERENCED_VARIABLE_NAMES`
  - `CU_JIT_REFERENCED_VARIABLE_COUNT`
  - `CU_JIT_OPTIMIZE_UNUSED_DEVICE_VARIABLES`

  Existing 11.x CUDA applications using JIT LTO will continue to work on the 12.0/R525 and later driver. The driver cuLink API support for JIT LTO is not removed but will only support

11.x LTOIR. The cuLink driver API enums for JIT LTO may be removed in the future so we recommend transitioning over to CUDA Toolkit 12.0 for JIT LTO.

12.0 LTOIR will not be supported by the driver cuLink APIs. 12.0 or later applications must use nvJitLink shared library to benefit from JIT LTO.

Refer to the CUDA 12.0 blog on JIT LTO for more details.

CUDA Tools

- CUDA-MEMCHECK is removed from CUDA 12.0, and has been replaced with Compute Sanitizer.

CUDA Compiler

- 32-bit compilation native and cross-compilation is removed from CUDA 12.0 and later Toolkit. Use the CUDA Toolkit from earlier releases for 32-bit compilation. CUDA Driver will continue to support running existing 32-bit applications on existing GPUs except Hopper. Hopper does not support 32-bit applications. Ada will be the last architecture with driver support for 32-bit applications.

Chapter 4. Known Issues

- For a cross-compile toolkit (such as linux64 host, aarch64 target), we are missing the host-side stub library for `libnvJitLink`. As a workaround, you can copy the `libnvJitlink.so` from the target install (for example, `/usr/local/cuda-12.1/targets/aarch64-linux/lib/libnvJitLink.so`) to the host install (`/usr/local/cuda-12.1/targets/aarch64-linux/lib/stubs/libnvJitLink.so`). Similarly if you are using the static library version (`/usr/local/cuda-12.1/targets/aarch64-linux/lib/libnvJitLink_static.a`), you can copy it from the target install (that is, install on the device) to the same path on the host install. For an SBSA cross-compile, replace “aarch64” with “sbsa” in the above copies.
- Tegra: Application binaries built with CUDA 11.8 or older toolkit using the LTO feature may fail when running with CUDA 12.0 compat driver. This issue will be fixed in a future release.

4.1. CUDA Tools

- NVIDIA Visual Profiler can’t remote into a target machine running Ubuntu 20.04.

Chapter 5. CUDA Libraries

This section covers CUDA Libraries release notes for 11.x releases.

- CUDA Math Libraries toolchain uses C++11 features, and a C++11-compatible standard library (libstdc++ >= 20150422) is required on the host.
- Support for the following compute capabilities is removed for all libraries:
  - sm_35 (Kepler)
  - sm_37 (Kepler)

5.1. cuBLAS Library

5.1.1. cuBLAS: Release 12.0 Update 1

- **New Features**
  - Improved performance on NVIDIA H100 SXM and NVIDIA H100 PCIe GPUs.
- **Known Issues**
  - For optimal performance on NVIDIA Hopper architecture, cuBLAS needs to allocate a bigger internal workspace (64 MiB) than on the previous architectures (8 MiB). In the current and previous releases, cuBLAS allocates 256 MiB. This will be addressed in a future release. A possible workaround is to set the `CUBLAS_WORKSPACE_CONFIG` environment variable to :32768:2 when running cuBLAS on NvMediaDlaPingById Hopper architecture.
- **Resolved Issues**
  - Reduced cuBLAS host-side overheads caused by not using the cublasLt heuristics cache.
  - Added forward-compatible single precision complex GEMM that does not require workspace.

5.1.2. cuBLAS: Release 12.0

- **New Features**
  - `cublasLtMatmul` now supports FP8 with a non-zero beta.
  - Added `int64` APIs to enable larger problem sizes; refer to 64-bit integer interface.
  - Added more Hopper-specific kernels for `cublasLtMatmul` with epilogues:
    - `CUBLASLT_EPILOGUE_BGRAD{A,B}`
    - `CUBLASLT_EPILOGUE_{RELU,GELU}_AUX`
    - `CUBLASLT_EPILOGUE_D{RELU,GELU}`
  - Improved Hopper performance on arm64-sbsa by adding Hopper kernels that were previously supported only on the x86_64 architecture for Windows and Linux.
- **Known Issues**
  - There are no forward compatible kernels for single precision complex gemms that do not require workspace. Support will be added in a later release.
- **Resolved Issues**
  - Fixed an issue on NVIDIA Ampere architecture and newer GPUs where `cublasLtMatmul` with epilogue `CUBLASLT_EPILOGUE_BGRAD{A,B}` and a nontrivial reduction scheme (that is, not `CUBLASLT_REDUCTION_SCHEME_NONE`) could return incorrect results for the bias gradient.
  - `cublasLtMatmul` for gemv-like cases (that is, m or n equals 1) might ignore bias with the `CUBLASLT_EPILOGUE_RELU_BIAS` and `CUBLASLT_EPILOGUE_BIAS` epilogues.

  Deprecations
  - Disallow including `cublas.h` and `cublas_v2.h` in the same translation unit.
  - Removed:
    - `CUBLAS_MATMUL_STAGES_16x80` and `CUBLAS_MATMUL_STAGES_64x80` from `cublasLtMatmulStages_t`. No kernels utilize these stages anymore.
    - `cublasLt3mMode_t`, `CUBLASLT_MATMUL_PREF_MATH_MODE_MASK`, and `CUBLASLT_MATMUL_PREF_GAUSSIAN_MODE_MASK` from `cublasLtMatmulPreferenceAttributes_t`. Instead, use the corresponding flags from `cublasLtNumericalImplFlags_t`.
    - `CUBLASLT_MATMUL_PREF_POINTER_MODE_MASK`, `CUBLASLT_MATMUL_PREF_EPILOGUE_MASK`, and `CUBLASLT_MATMUL_PREF_SM_COUNT_TARGET` from `cublasLtMatmulPreferenceAttributes_t`. The corresponding parameters are taken directly from `cublasLtMatmulDesc_t`.
    - `CUBLASLT_POINTER_MODE_MASK_NO_FILTERING` from `cublasLtPointerModeMask_t`. This mask was only applicable to `CUBLASLT_MATMUL_PREF_MATH_MODE_MASK` which was removed.

5.2. cuFFT Library

5.2.1. cuFFT: Release 12.0 Update 1

- **Resolved Issues**
  - Scratch space requirements for multi-GPU, single-batch, 1D FFTs was reduced.

5.2.2. cuFFT: Release 12.0

- **New Features**
  - PTX JIT kernel compilation allowed the addition of many new accelerated cases for Maxwell, Pascal, Volta and Turing architectures.
- **Known Issues**
  - cuFFT plan generation time increases due to PTX JIT compiling. Refer to Plan Initialization TIme.
- **Resolved Issues**
  - cuFFT plans had an unintentional small memory overhead (of a few kB) per plan. This is resolved.

5.3. cuSPARSE Library

5.3.1. cuSPARSE: Release 12.0 Update 1

- **New Features**
  - `cusparseSDDMM()` now supports mixed precision computation.
  - Improved `cusparseSpMM()` alg2 mixed-precision performance on some matrices on NVIDIA Ampere architecture GPUs.
  - Improved cusparseSpMV() performance with a new load balancing algorithm.
  - `cusparseSpSV()` and `cusparseSpSM()` now support in-place computation, namely the output and input vectors/matrices have the same memory address.

5.3.2. cuSPARSE: Release 12.0

- **New Features**
  - JIT LTO functionalities (`cusparseSpMMOp()`) switched from driver to nvJitLto library. Starting from CUDA 12.0 the user needs to link to `libnvJitLto.so`, see cuSPARSE documentation. JIT LTO performance has also been improved for `cusparseSpMMOpPlan()`.
  - Introduced const descriptors for the Generic APIs, for example, `cusparseConstSpVecGet()`. Now the Generic APIs interface clearly declares when a descriptor and its data are modified by the cuSPARSE functions.
  - Added two new algorithms to `cusparseSpGEMM()` with lower memory utilization. The first algorithm computes a strict bound on the number of intermediate product, while the second one allows partitioning the computation in chunks.
  - Added `int8_t` support to `cusparseGather()`, `cusparseScatter()`, and `cusparseCsr2cscEx2()`.
  - Improved `cusparseSpSV()` performance for both the analysis and the solving phases.
  - Improved `cusparseSpSM()` performance for both the analysis and the solving phases.
  - Improved `cusparseSDDMM()` performance and added support for batch computation.
  - Improved `cusparseCsr2cscEx2()` performance.
- **Resolved Issues**
  - `cusparseSpSV()` and `cusparseSpSM()` could produce wrong results.
  - `cusparseDnMatGetStridedBatch()` did not accept `batchStride == 0`.
- **Deprecations**
  - Removed deprecated CUDA 11.x APIs, enumerators, and descriptors.

5.4. Math Library

5.4.1. CUDA Math: Release 12.0

- **New Features**
  - Introduced new integer/fp16/bf16 CUDA Math APIs to help expose performance benefits of new DPX instructions. Refer to https://docs.nvidia.com/cuda/cuda-math-api/index.html.

  Known Issues
  - Double precision inputs that cause the double precision division algorithm in the default 'round to nearest even mode' produce spurious overflow: an infinite result is delivered where `DBL_MAX 0x7FEF_FFFF_FFFF_FFFF` is expected. Affected CUDA Math APIs: `__ddiv_rn()`. Affected CUDA language operation: double precision / operation in the device code.
- **Deprecations**
  - All previously deprecated undocumented APIs are removed from CUDA 12.0.

5.5. NVIDIA Performance Primitives (NPP)

5.5.1. NPP: Release 12.0

- **Deprecations**
  - Deprecating non-CTX API support from next release.
- **Resolved Issues**
  - A performance issue with the NPP `ResizeSqrPixel` API is now fixed and shows improved performance.

5.6. nvJPEG Library

5.6.1. nvJPEG: Release 12.0

- **New Features**
  - Immproved the GPU Memory optimisation for the nvJPEG codec.
- **Resolved Issues**
  - An issue that causes runtime failures when `nvJPEGDecMultipleInstances` was tested with a large number of threads is resolved.
  - An issue with CMYK four component color conversion is now resolved.
- **Known Issues**
  - Backend `NVJPEG_BACKEND_GPU_HYBRID` - Unable to handle bitstreams with extra scans lengths.
- **Deprecations**
  - The reuse of Huffman table in Encoder (`nvjpegEncoderParamsCopyHuffmanTables`).

Chapter 6. Notices

6.1. Notice

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